

Overpopulation vs. Underpopulation: Insights from Total Fertility Rate Data (1960-2021)

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Case Study Outline:

- Motivating Question: Which issue will be more significant in the coming decades, overpopulation or underpopulation?
- Hypothesis: In the coming decades, most countries will need to address an *underpopulation* problem – not an overpopulation one.
- Data set: For this case study, I used a data set from The World Bank. It contains a list of countries, in addition to their respective total fertility rates from 1960 to 2021.

Abstract:

- The Total Fertility Rate (TFR) is a measure of the average number of children that would be born to a woman over her lifetime if she were to experience the exact current age-specific fertility rates through her lifetime and were to live from birth until the end of her reproductive life. It is often said that the world is experiencing, or will experience an overpopulation problem. Due to the dramatic drop in TFRs across nearly every country for the last several decades, we hypothesize that most countries will need to address an underpopulation problem – not an overpopulation one.

Install required packages

```
library(tidyverse) # helps wrangle data
```

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.2      v readr      2.1.4
## v forcats    1.0.0      v stringr   1.5.0
## v ggplot2     3.4.2      v tibble    3.2.1
## v lubridate  1.9.2      v tidyr     1.3.0
## v purrr      1.0.1
```

```
## -- Conflicts ----- tidyverse_conflicts() --
```

```
## x dplyr::filter() masks stats::filter()
```

```
## x dplyr::lag() masks stats::lag()
```

```
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(lubridate) # helps wrangle date attributes
```

```
library(ggplot2) # helps visualize data
```

```
library(readxl) # helps read data from Excel files
```

```
library(scales) # helps scale data, format labels, and create color palettes
```

```
##
```

```
## Attaching package: 'scales'
```

```
##
```

```
## The following object is masked from 'package:purrr':
```

```
##
```

```
## discard
```

```
##
```

```
## The following object is masked from 'package:readr':
```

```
##
##      col_factor
library(dplyr) # helps manipulate data frames

getwd() # displays working directory

## [1] "/Users/bradleycardona/Documents/Repos/fertility_rates"
# set working directory to simplify calls to data
# setwd("~/Documents/data_analytics/fertility_rate_case_study/")
```

Step 1: Collect data

```
fertility_rates <- read_xls("fertility_rates.xls")
head(fertility_rates)

## # A tibble: 6 x 67
##   `Country Name` `Country Code` `Indicator Name` `Indicator Code` `1960` `1961`
##   <chr>          <chr>          <chr>          <chr>          <dbl> <dbl>
## 1 Aruba          ABW          Fertility rate,~ SP.DYN.TFRT.IN    4.82  4.66
## 2 Africa Eastern~ AFE          Fertility rate,~ SP.DYN.TFRT.IN    6.72  6.74
## 3 Afghanistan    AFG          Fertility rate,~ SP.DYN.TFRT.IN    7.28  7.28
## 4 Africa Western~ AFW          Fertility rate,~ SP.DYN.TFRT.IN    6.46  6.47
## 5 Angola          AGO          Fertility rate,~ SP.DYN.TFRT.IN    6.71  6.79
## 6 Albania         ALB          Fertility rate,~ SP.DYN.TFRT.IN    6.46  6.35
## # i 61 more variables: `1962` <dbl>, `1963` <dbl>, `1964` <dbl>, `1965` <dbl>,
## #   `1966` <dbl>, `1967` <dbl>, `1968` <dbl>, `1969` <dbl>, `1970` <dbl>,
## #   `1971` <dbl>, `1972` <dbl>, `1973` <dbl>, `1974` <dbl>, `1975` <dbl>,
## #   `1976` <dbl>, `1977` <dbl>, `1978` <dbl>, `1979` <dbl>, `1980` <dbl>,
## #   `1981` <dbl>, `1982` <dbl>, `1983` <dbl>, `1984` <dbl>, `1985` <dbl>,
## #   `1986` <dbl>, `1987` <dbl>, `1988` <dbl>, `1989` <dbl>, `1990` <dbl>,
## #   `1991` <dbl>, `1992` <dbl>, `1993` <dbl>, `1994` <dbl>, `1995` <dbl>, ...
```

Step 2: Wrangle data, look for any incongruencies

```
colnames(fertility_rates) # Column names

## [1] "Country Name" "Country Code" "Indicator Name" "Indicator Code"
## [5] "1960"         "1961"         "1962"         "1963"
## [9] "1964"         "1965"         "1966"         "1967"
## [13] "1968"         "1969"         "1970"         "1971"
## [17] "1972"         "1973"         "1974"         "1975"
## [21] "1976"         "1977"         "1978"         "1979"
## [25] "1980"         "1981"         "1982"         "1983"
## [29] "1984"         "1985"         "1986"         "1987"
## [33] "1988"         "1989"         "1990"         "1991"
## [37] "1992"         "1993"         "1994"         "1995"
## [41] "1996"         "1997"         "1998"         "1999"
## [45] "2000"         "2001"         "2002"         "2003"
## [49] "2004"         "2005"         "2006"         "2007"
## [53] "2008"         "2009"         "2010"         "2011"
## [57] "2012"         "2013"         "2014"         "2015"
## [61] "2016"         "2017"         "2018"         "2019"
## [65] "2020"         "2021"         "2022"

nrow(fertility_rates) # Number of rows

## [1] 266
```

```
dim(fertility_rates) # Dimensionss
```

```
## [1] 266 67
```

```
head(fertility_rates) # First 6 rows of data frame
```

```
## # A tibble: 6 x 67
##   `Country Name` `Country Code` `Indicator Name` `Indicator Code` `1960` `1961`
##   <chr>          <chr>          <chr>          <chr>          <dbl> <dbl>
## 1 Aruba          ABW            Fertility rate,~ SP.DYN.TFRT.IN    4.82  4.66
## 2 Africa Eastern~ AFE            Fertility rate,~ SP.DYN.TFRT.IN    6.72  6.74
## 3 Afghanistan    AFG            Fertility rate,~ SP.DYN.TFRT.IN    7.28  7.28
## 4 Africa Western~ AFW            Fertility rate,~ SP.DYN.TFRT.IN    6.46  6.47
## 5 Angola          AGO            Fertility rate,~ SP.DYN.TFRT.IN    6.71  6.79
## 6 Albania         ALB            Fertility rate,~ SP.DYN.TFRT.IN    6.46  6.35
## # i 61 more variables: `1962` <dbl>, `1963` <dbl>, `1964` <dbl>, `1965` <dbl>,
## #   `1966` <dbl>, `1967` <dbl>, `1968` <dbl>, `1969` <dbl>, `1970` <dbl>,
## #   `1971` <dbl>, `1972` <dbl>, `1973` <dbl>, `1974` <dbl>, `1975` <dbl>,
## #   `1976` <dbl>, `1977` <dbl>, `1978` <dbl>, `1979` <dbl>, `1980` <dbl>,
## #   `1981` <dbl>, `1982` <dbl>, `1983` <dbl>, `1984` <dbl>, `1985` <dbl>,
## #   `1986` <dbl>, `1987` <dbl>, `1988` <dbl>, `1989` <dbl>, `1990` <dbl>,
## #   `1991` <dbl>, `1992` <dbl>, `1993` <dbl>, `1994` <dbl>, `1995` <dbl>, ...
```

```
str(fertility_rates) # Columns and respective data types (numeric, character, etc)
```

```
## tibble [266 x 67] (S3: tbl_df/tbl/data.frame)
## $ Country Name : chr [1:266] "Aruba" "Africa Eastern and Southern" "Afghanistan" "Africa Western"
## $ Country Code : chr [1:266] "ABW" "AFE" "AFG" "AFW" ...
## $ Indicator Name: chr [1:266] "Fertility rate, total (births per woman)" "Fertility rate, total"
## $ Indicator Code: chr [1:266] "SP.DYN.TFRT.IN" "SP.DYN.TFRT.IN" "SP.DYN.TFRT.IN" "SP.DYN.TFRT.IN"
## $ 1960          : num [1:266] 4.82 6.72 7.28 6.46 6.71 ...
## $ 1961          : num [1:266] 4.66 6.74 7.28 6.47 6.79 ...
## $ 1962          : num [1:266] 4.47 6.76 7.29 6.49 6.87 ...
## $ 1963          : num [1:266] 4.27 6.78 7.3 6.51 6.95 ...
## $ 1964          : num [1:266] 4.06 6.79 7.3 6.53 7.04 ...
## $ 1965          : num [1:266] 3.84 6.8 7.3 6.54 7.12 ...
## $ 1966          : num [1:266] 3.62 6.81 7.32 6.56 7.19 ...
## $ 1967          : num [1:266] 3.42 6.82 7.34 6.59 7.27 ...
## $ 1968          : num [1:266] 3.23 6.83 7.36 6.61 7.33 ...
## $ 1969          : num [1:266] 3.05 6.83 7.39 6.64 7.39 ...
## $ 1970          : num [1:266] 2.91 6.84 7.4 6.66 7.43 ...
## $ 1971          : num [1:266] 2.79 6.84 7.43 6.7 7.47 ...
## $ 1972          : num [1:266] 2.69 6.84 7.45 6.73 7.49 ...
## $ 1973          : num [1:266] 2.61 6.83 7.49 6.76 7.5 ...
## $ 1974          : num [1:266] 2.55 6.82 7.53 6.8 7.5 ...
## $ 1975          : num [1:266] 2.51 6.81 7.54 6.84 7.49 ...
## $ 1976          : num [1:266] 2.47 6.79 7.56 6.86 7.49 ...
## $ 1977          : num [1:266] 2.45 6.77 7.59 6.9 7.47 ...
## $ 1978          : num [1:266] 2.42 6.75 7.6 6.92 7.47 ...
## $ 1979          : num [1:266] 2.41 6.73 7.61 6.91 7.46 ...
## $ 1980          : num [1:266] 2.39 6.7 7.59 6.9 7.46 ...
## $ 1981          : num [1:266] 2.38 6.67 7.57 6.88 7.46 ...
## $ 1982          : num [1:266] 2.36 6.64 7.55 6.86 7.46 ...
## $ 1983          : num [1:266] 2.35 6.6 7.54 6.83 7.46 ...
## $ 1984          : num [1:266] 2.34 6.57 7.51 6.78 7.46 ...
## $ 1985          : num [1:266] 2.33 6.51 7.52 6.73 7.45 ...
## $ 1986          : num [1:266] 2.32 6.46 7.52 6.68 7.43 ...
## $ 1987          : num [1:266] 2.31 6.42 7.53 6.64 7.41 ...
## $ 1988          : num [1:266] 2.29 6.34 7.53 6.6 7.37 ...
```

```
## $ 1989      : num [1:266] 2.27 6.26 7.53 6.57 7.33 ...
## $ 1990      : num [1:266] 2.3 6.17 7.57 6.52 7.27 ...
## $ 1991      : num [1:266] 2.31 6.1 7.61 6.47 7.21 ...
## $ 1992      : num [1:266] 2.28 6.03 7.67 6.42 7.14 ...
## $ 1993      : num [1:266] 2.23 5.96 7.72 6.36 7.07 ...
## $ 1994      : num [1:266] 2.12 5.9 7.72 6.3 6.99 ...
## $ 1995      : num [1:266] 2.19 5.84 7.71 6.24 6.92 ...
## $ 1996      : num [1:266] 2.15 5.77 7.71 6.17 6.85 ...
## $ 1997      : num [1:266] 2.14 5.7 7.67 6.1 6.79 ...
## $ 1998      : num [1:266] 1.96 5.64 7.64 6.04 6.73 ...
## $ 1999      : num [1:266] 1.87 5.59 7.6 6.03 6.68 ...
## $ 2000      : num [1:266] 1.9 5.52 7.53 6.02 6.64 ...
## $ 2001      : num [1:266] 1.83 5.48 7.45 6 6.6 ...
## $ 2002      : num [1:266] 1.76 5.43 7.34 5.97 6.57 ...
## $ 2003      : num [1:266] 1.75 5.38 7.22 5.93 6.53 ...
## $ 2004      : num [1:266] 1.68 5.34 7.07 5.89 6.5 ...
## $ 2005      : num [1:266] 1.78 5.31 6.91 5.86 6.46 ...
## $ 2006      : num [1:266] 1.91 5.27 6.72 5.85 6.42 ...
## $ 2007      : num [1:266] 1.93 5.22 6.53 5.82 6.37 ...
## $ 2008      : num [1:266] 1.94 5.19 6.38 5.79 6.32 ...
## $ 2009      : num [1:266] 1.92 5.12 6.24 5.75 6.26 ...
## $ 2010      : num [1:266] 1.94 5.04 6.1 5.7 6.19 ...
## $ 2011      : num [1:266] 1.96 4.96 5.96 5.65 6.12 ...
## $ 2012      : num [1:266] 2.03 4.88 5.83 5.58 6.04 ...
## $ 2013      : num [1:266] 2.12 4.81 5.7 5.51 5.95 ...
## $ 2014      : num [1:266] 2.15 4.74 5.56 5.44 5.86 ...
## $ 2015      : num [1:266] 1.97 4.68 5.41 5.39 5.77 ...
## $ 2016      : num [1:266] 1.95 4.62 5.26 5.33 5.69 ...
## $ 2017      : num [1:266] 1.84 4.57 5.13 5.26 5.6 ...
## $ 2018      : num [1:266] 1.59 4.53 5 5.19 5.52 ...
## $ 2019      : num [1:266] 1.49 4.48 4.87 5.12 5.44 ...
## $ 2020      : num [1:266] 1.32 4.42 4.75 5.05 5.37 ...
## $ 2021      : num [1:266] 1.18 4.35 4.64 4.98 5.3 ...
## $ 2022      : logi [1:266] NA NA NA NA NA NA ...
```

```
summary(fertility_rates) # Statistical summary of data. Mainly for numerics
```

```
## Country Name      Country Code      Indicator Name      Indicator Code
## Length:266        Length:266        Length:266        Length:266
## Class :character   Class :character   Class :character   Class :character
## Mode :character    Mode :character    Mode :character    Mode :character
##
##
##
##
##      1960      1961      1962      1963
## Min.   :1.940   Min.   :1.940   Min.   :1.790   Min.   :1.820
## 1st Qu.:4.240   1st Qu.:4.082   1st Qu.:4.190   1st Qu.:4.160
## Median :6.078   Median :6.083   Median :6.085   Median :6.147
## Mean   :5.444   Mean   :5.423   Mean   :5.456   Mean   :5.488
## 3rd Qu.:6.721   3rd Qu.:6.725   3rd Qu.:6.747   3rd Qu.:6.771
## Max.   :8.234   Max.   :8.266   Max.   :8.285   Max.   :8.309
## NA's   :13      NA's   :14      NA's   :13      NA's   :14
##      1964      1965      1966      1967
## Min.   :1.790   Min.   :1.740   Min.   :1.580   Min.   :1.800
## 1st Qu.:4.059   1st Qu.:3.842   1st Qu.:3.709   1st Qu.:3.637
## Median :6.019   Median :5.960   Median :5.907   Median :5.825
## Mean   :5.426   Mean   :5.381   Mean   :5.323   Mean   :5.269
## 3rd Qu.:6.734   3rd Qu.:6.733   3rd Qu.:6.707   3rd Qu.:6.683
```

##	Max.	:8.330	Max.	:8.344	Max.	:8.356	Max.	:8.340
##	NA's	:13	NA's	:13	NA's	:13	NA's	:13
##		1968		1969		1970		1971
##	Min.	:1.830	Min.	:1.870	Min.	:1.823	Min.	:1.680
##	1st Qu.:	3.460	1st Qu.:	3.284	1st Qu.:	3.188	1st Qu.:	3.144
##	Median	:5.788	Median	:5.738	Median	:5.636	Median	:5.534
##	Mean	:5.227	Mean	:5.173	Mean	:5.115	Mean	:5.057
##	3rd Qu.:	6.682	3rd Qu.:	6.679	3rd Qu.:	6.680	3rd Qu.:	6.654
##	Max.	:8.315	Max.	:8.264	Max.	:8.238	Max.	:8.264
##	NA's	:13	NA's	:13	NA's	:12	NA's	:12
##		1972		1973		1974		1975
##	Min.	:1.580	Min.	:1.490	Min.	:1.510	Min.	:1.450
##	1st Qu.:	3.060	1st Qu.:	2.933	1st Qu.:	2.889	1st Qu.:	2.760
##	Median	:5.314	Median	:5.252	Median	:5.086	Median	:4.975
##	Mean	:4.987	Mean	:4.903	Mean	:4.831	Mean	:4.742
##	3rd Qu.:	6.599	3rd Qu.:	6.630	3rd Qu.:	6.608	3rd Qu.:	6.586
##	Max.	:8.299	Max.	:8.304	Max.	:8.335	Max.	:8.401
##	NA's	:12	NA's	:12	NA's	:12	NA's	:11
##		1976		1977		1978		1979
##	Min.	:1.450	Min.	:1.400	Min.	:1.380	Min.	:1.380
##	1st Qu.:	2.731	1st Qu.:	2.659	1st Qu.:	2.577	1st Qu.:	2.554
##	Median	:4.810	Median	:4.706	Median	:4.534	Median	:4.493
##	Mean	:4.678	Mean	:4.610	Mean	:4.555	Mean	:4.522
##	3rd Qu.:	6.554	3rd Qu.:	6.512	3rd Qu.:	6.474	3rd Qu.:	6.463
##	Max.	:8.444	Max.	:8.504	Max.	:8.520	Max.	:8.671
##	NA's	:10	NA's	:11	NA's	:11	NA's	:11
##		1980		1981		1982		1983
##	Min.	:1.440	Min.	:1.430	Min.	:1.410	Min.	:1.330
##	1st Qu.:	2.471	1st Qu.:	2.423	1st Qu.:	2.384	1st Qu.:	2.373
##	Median	:4.426	Median	:4.314	Median	:4.216	Median	:4.095
##	Mean	:4.479	Mean	:4.425	Mean	:4.381	Mean	:4.326
##	3rd Qu.:	6.399	3rd Qu.:	6.375	3rd Qu.:	6.371	3rd Qu.:	6.303
##	Max.	:8.710	Max.	:8.752	Max.	:8.793	Max.	:8.828
##	NA's	:11	NA's	:11	NA's	:10	NA's	:11
##		1984		1985		1986		1987
##	Min.	:1.290	Min.	:1.370	Min.	:1.350	Min.	:1.311
##	1st Qu.:	2.340	1st Qu.:	2.324	1st Qu.:	2.321	1st Qu.:	2.288
##	Median	:4.014	Median	:3.959	Median	:3.962	Median	:3.788
##	Mean	:4.270	Mean	:4.216	Mean	:4.164	Mean	:4.103
##	3rd Qu.:	6.229	3rd Qu.:	6.138	3rd Qu.:	6.018	3rd Qu.:	5.856
##	Max.	:8.853	Max.	:8.864	Max.	:8.858	Max.	:8.833
##	NA's	:11	NA's	:11	NA's	:11	NA's	:10
##		1988		1989		1990		1991
##	Min.	:1.360	Min.	:1.296	Min.	:1.272	Min.	:1.281
##	1st Qu.:	2.280	1st Qu.:	2.244	1st Qu.:	2.304	1st Qu.:	2.187
##	Median	:3.711	Median	:3.583	Median	:3.471	Median	:3.402
##	Mean	:4.050	Mean	:3.983	Mean	:3.931	Mean	:3.853
##	3rd Qu.:	5.798	3rd Qu.:	5.692	3rd Qu.:	5.604	3rd Qu.:	5.474
##	Max.	:8.786	Max.	:8.713	Max.	:8.606	Max.	:8.459
##	NA's	:11	NA's	:11	NA's	:9	NA's	:10
##		1992		1993		1994		1995
##	Min.	:1.290	Min.	:1.250	Min.	:1.190	Min.	:1.160
##	1st Qu.:	2.120	1st Qu.:	2.034	1st Qu.:	1.987	1st Qu.:	1.967
##	Median	:3.318	Median	:3.208	Median	:3.121	Median	:3.072
##	Mean	:3.776	Mean	:3.699	Mean	:3.623	Mean	:3.543
##	3rd Qu.:	5.314	3rd Qu.:	5.203	3rd Qu.:	5.046	3rd Qu.:	4.884
##	Max.	:8.272	Max.	:8.048	Max.	:7.989	Max.	:7.962
##	NA's	:9	NA's	:10	NA's	:10	NA's	:9

```
##      1996      1997      1998      1999
## Min.   :1.140 Min.   :1.090 Min.   :1.016 Min.   :0.981
## 1st Qu.:1.931 1st Qu.:1.896 1st Qu.:1.860 1st Qu.:1.817
## Median :3.014 Median :2.940 Median :2.815 Median :2.767
## Mean   :3.476 Mean   :3.408 Mean   :3.339 Mean   :3.288
## 3rd Qu.:4.771 3rd Qu.:4.660 3rd Qu.:4.576 3rd Qu.:4.516
## Max.   :7.985 Max.   :7.965 Max.   :7.817 Max.   :7.752
## NA's   :10    NA's   :9     NA's   :9     NA's   :9
##      2000      2001      2002      2003
## Min.   :0.912 Min.   :0.840 Min.   :0.800 Min.   :0.792
## 1st Qu.:1.855 1st Qu.:1.800 1st Qu.:1.790 1st Qu.:1.786
## Median :2.716 Median :2.667 Median :2.623 Median :2.583
## Mean   :3.235 Mean   :3.182 Mean   :3.136 Mean   :3.095
## 3rd Qu.:4.434 3rd Qu.:4.375 3rd Qu.:4.304 3rd Qu.:4.234
## Max.   :7.732 Max.   :7.695 Max.   :7.671 Max.   :7.654
## NA's   :7     NA's   :8     NA's   :8     NA's   :8
##      2004      2005      2006      2007
## Min.   :0.800 Min.   :0.834 Min.   :0.874 Min.   :0.918
## 1st Qu.:1.781 1st Qu.:1.786 1st Qu.:1.793 1st Qu.:1.823
## Median :2.582 Median :2.552 Median :2.503 Median :2.510
## Mean   :3.068 Mean   :3.033 Mean   :3.007 Mean   :2.991
## 3rd Qu.:4.129 3rd Qu.:3.983 3rd Qu.:3.850 3rd Qu.:3.863
## Max.   :7.634 Max.   :7.615 Max.   :7.579 Max.   :7.559
## NA's   :8     NA's   :7     NA's   :7     NA's   :7
##      2008      2009      2010      2011
## Min.   :0.947 Min.   :0.986 Min.   :1.042 Min.   :1.115
## 1st Qu.:1.838 1st Qu.:1.823 1st Qu.:1.802 1st Qu.:1.781
## Median :2.481 Median :2.437 Median :2.397 Median :2.334
## Mean   :2.983 Mean   :2.957 Mean   :2.924 Mean   :2.895
## 3rd Qu.:3.877 3rd Qu.:3.865 3rd Qu.:3.880 3rd Qu.:3.836
## Max.   :7.539 Max.   :7.513 Max.   :7.485 Max.   :7.449
## NA's   :7     NA's   :7     NA's   :7     NA's   :8
##      2012      2013      2014      2015
## Min.   :1.103 Min.   :1.080 Min.   :1.205 Min.   :1.186
## 1st Qu.:1.792 1st Qu.:1.750 1st Qu.:1.751 1st Qu.:1.734
## Median :2.312 Median :2.328 Median :2.300 Median :2.260
## Mean   :2.868 Mean   :2.835 Mean   :2.813 Mean   :2.775
## 3rd Qu.:3.753 3rd Qu.:3.688 3rd Qu.:3.632 3rd Qu.:3.560
## Max.   :7.400 Max.   :7.344 Max.   :7.279 Max.   :7.211
## NA's   :6     NA's   :8     NA's   :8     NA's   :7
##      2016      2017      2018      2019
## Min.   :0.987 Min.   :0.872 Min.   :0.917 Min.   :0.918
## 1st Qu.:1.725 1st Qu.:1.693 1st Qu.:1.648 1st Qu.:1.612
## Median :2.245 Median :2.211 Median :2.175 Median :2.139
## Mean   :2.742 Mean   :2.694 Mean   :2.653 Mean   :2.611
## 3rd Qu.:3.492 3rd Qu.:3.432 3rd Qu.:3.403 3rd Qu.:3.333
## Max.   :7.141 Max.   :7.084 Max.   :7.023 Max.   :6.961
## NA's   :8     NA's   :8     NA's   :8     NA's   :8
##      2020      2021      2022
## Min.   :0.837 Min.   :0.772 Mode:logical
## 1st Qu.:1.572 1st Qu.:1.583 NA's:266
## Median :2.103 Median :2.088
## Mean   :2.560 Mean   :2.542
## 3rd Qu.:3.271 3rd Qu.:3.288
## Max.   :6.892 Max.   :6.820
## NA's   :7     NA's   :8
```

```
# delete two columns: "Indicator Name" and "Indicator Code"
fertility_rates <- fertility_rates %>%
```

```
select(-c("Indicator Name", "Indicator Code"))
```

Step 3: Clean up data and prepare for analysis

Inspect the new table that has been created

```
colnames(fertility_rates) # Column names
```

```
## [1] "Country Name" "Country Code" "1960"          "1961"          "1962"
## [6] "1963"          "1964"          "1965"          "1966"          "1967"
## [11] "1968"          "1969"          "1970"          "1971"          "1972"
## [16] "1973"          "1974"          "1975"          "1976"          "1977"
## [21] "1978"          "1979"          "1980"          "1981"          "1982"
## [26] "1983"          "1984"          "1985"          "1986"          "1987"
## [31] "1988"          "1989"          "1990"          "1991"          "1992"
## [36] "1993"          "1994"          "1995"          "1996"          "1997"
## [41] "1998"          "1999"          "2000"          "2001"          "2002"
## [46] "2003"          "2004"          "2005"          "2006"          "2007"
## [51] "2008"          "2009"          "2010"          "2011"          "2012"
## [56] "2013"          "2014"          "2015"          "2016"          "2017"
## [61] "2018"          "2019"          "2020"          "2021"          "2022"
```

```
nrow(fertility_rates) # Number of rows
```

```
## [1] 266
```

```
dim(fertility_rates) # Dimensions
```

```
## [1] 266 65
```

```
head(fertility_rates) # First 6 rows of data frame
```

```
## # A tibble: 6 x 65
##   `Country Name` `Country Code` `1960` `1961` `1962` `1963` `1964` `1965` `1966`
##   <chr>         <chr>         <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
## 1 Aruba         ABW             4.82  4.66  4.47  4.27  4.06  3.84  3.62
## 2 Africa Easter~ AFE             6.72  6.74  6.76  6.78  6.79  6.80  6.81
## 3 Afghanistan  AFG             7.28  7.28  7.29  7.30  7.30  7.30  7.32
## 4 Africa Wester~ AFW             6.46  6.47  6.49  6.51  6.53  6.54  6.56
## 5 Angola       AGO             6.71  6.79  6.87  6.95  7.04  7.12  7.19
## 6 Albania      ALB             6.46  6.35  6.21  6.05  5.85  5.62  5.46
## # i 56 more variables: `1967` <dbl>, `1968` <dbl>, `1969` <dbl>, `1970` <dbl>,
## #   `1971` <dbl>, `1972` <dbl>, `1973` <dbl>, `1974` <dbl>, `1975` <dbl>,
## #   `1976` <dbl>, `1977` <dbl>, `1978` <dbl>, `1979` <dbl>, `1980` <dbl>,
## #   `1981` <dbl>, `1982` <dbl>, `1983` <dbl>, `1984` <dbl>, `1985` <dbl>,
## #   `1986` <dbl>, `1987` <dbl>, `1988` <dbl>, `1989` <dbl>, `1990` <dbl>,
## #   `1991` <dbl>, `1992` <dbl>, `1993` <dbl>, `1994` <dbl>, `1995` <dbl>,
## #   `1996` <dbl>, `1997` <dbl>, `1998` <dbl>, `1999` <dbl>, `2000` <dbl>, ...
```

```
str(fertility_rates) # Columns and respective data types (numeric, character, etc)
```

```
## tibble [266 x 65] (S3: tbl_df/tbl/data.frame)
## $ Country Name: chr [1:266] "Aruba" "Africa Eastern and Southern" "Afghanistan" "Africa Western
## $ Country Code: chr [1:266] "ABW" "AFE" "AFG" "AFW" ...
## $ 1960         : num [1:266] 4.82 6.72 7.28 6.46 6.71 ...
## $ 1961         : num [1:266] 4.66 6.74 7.28 6.47 6.79 ...
## $ 1962         : num [1:266] 4.47 6.76 7.29 6.49 6.87 ...
## $ 1963         : num [1:266] 4.27 6.78 7.3 6.51 6.95 ...
## $ 1964         : num [1:266] 4.06 6.79 7.3 6.53 7.04 ...
## $ 1965         : num [1:266] 3.84 6.8 7.3 6.54 7.12 ...
## $ 1966         : num [1:266] 3.62 6.81 7.32 6.56 7.19 ...
```

```

## $ 1967      : num [1:266] 3.42 6.82 7.34 6.59 7.27 ...
## $ 1968      : num [1:266] 3.23 6.83 7.36 6.61 7.33 ...
## $ 1969      : num [1:266] 3.05 6.83 7.39 6.64 7.39 ...
## $ 1970      : num [1:266] 2.91 6.84 7.4 6.66 7.43 ...
## $ 1971      : num [1:266] 2.79 6.84 7.43 6.7 7.47 ...
## $ 1972      : num [1:266] 2.69 6.84 7.45 6.73 7.49 ...
## $ 1973      : num [1:266] 2.61 6.83 7.49 6.76 7.5 ...
## $ 1974      : num [1:266] 2.55 6.82 7.53 6.8 7.5 ...
## $ 1975      : num [1:266] 2.51 6.81 7.54 6.84 7.49 ...
## $ 1976      : num [1:266] 2.47 6.79 7.56 6.86 7.49 ...
## $ 1977      : num [1:266] 2.45 6.77 7.59 6.9 7.47 ...
## $ 1978      : num [1:266] 2.42 6.75 7.6 6.92 7.47 ...
## $ 1979      : num [1:266] 2.41 6.73 7.61 6.91 7.46 ...
## $ 1980      : num [1:266] 2.39 6.7 7.59 6.9 7.46 ...
## $ 1981      : num [1:266] 2.38 6.67 7.57 6.88 7.46 ...
## $ 1982      : num [1:266] 2.36 6.64 7.55 6.86 7.46 ...
## $ 1983      : num [1:266] 2.35 6.6 7.54 6.83 7.46 ...
## $ 1984      : num [1:266] 2.34 6.57 7.51 6.78 7.46 ...
## $ 1985      : num [1:266] 2.33 6.51 7.52 6.73 7.45 ...
## $ 1986      : num [1:266] 2.32 6.46 7.52 6.68 7.43 ...
## $ 1987      : num [1:266] 2.31 6.42 7.53 6.64 7.41 ...
## $ 1988      : num [1:266] 2.29 6.34 7.53 6.6 7.37 ...
## $ 1989      : num [1:266] 2.27 6.26 7.53 6.57 7.33 ...
## $ 1990      : num [1:266] 2.3 6.17 7.57 6.52 7.27 ...
## $ 1991      : num [1:266] 2.31 6.1 7.61 6.47 7.21 ...
## $ 1992      : num [1:266] 2.28 6.03 7.67 6.42 7.14 ...
## $ 1993      : num [1:266] 2.23 5.96 7.72 6.36 7.07 ...
## $ 1994      : num [1:266] 2.12 5.9 7.72 6.3 6.99 ...
## $ 1995      : num [1:266] 2.19 5.84 7.71 6.24 6.92 ...
## $ 1996      : num [1:266] 2.15 5.77 7.71 6.17 6.85 ...
## $ 1997      : num [1:266] 2.14 5.7 7.67 6.1 6.79 ...
## $ 1998      : num [1:266] 1.96 5.64 7.64 6.04 6.73 ...
## $ 1999      : num [1:266] 1.87 5.59 7.6 6.03 6.68 ...
## $ 2000      : num [1:266] 1.9 5.52 7.53 6.02 6.64 ...
## $ 2001      : num [1:266] 1.83 5.48 7.45 6 6.6 ...
## $ 2002      : num [1:266] 1.76 5.43 7.34 5.97 6.57 ...
## $ 2003      : num [1:266] 1.75 5.38 7.22 5.93 6.53 ...
## $ 2004      : num [1:266] 1.68 5.34 7.07 5.89 6.5 ...
## $ 2005      : num [1:266] 1.78 5.31 6.91 5.86 6.46 ...
## $ 2006      : num [1:266] 1.91 5.27 6.72 5.85 6.42 ...
## $ 2007      : num [1:266] 1.93 5.22 6.53 5.82 6.37 ...
## $ 2008      : num [1:266] 1.94 5.19 6.38 5.79 6.32 ...
## $ 2009      : num [1:266] 1.92 5.12 6.24 5.75 6.26 ...
## $ 2010      : num [1:266] 1.94 5.04 6.1 5.7 6.19 ...
## $ 2011      : num [1:266] 1.96 4.96 5.96 5.65 6.12 ...
## $ 2012      : num [1:266] 2.03 4.88 5.83 5.58 6.04 ...
## $ 2013      : num [1:266] 2.12 4.81 5.7 5.51 5.95 ...
## $ 2014      : num [1:266] 2.15 4.74 5.56 5.44 5.86 ...
## $ 2015      : num [1:266] 1.97 4.68 5.41 5.39 5.77 ...
## $ 2016      : num [1:266] 1.95 4.62 5.26 5.33 5.69 ...
## $ 2017      : num [1:266] 1.84 4.57 5.13 5.26 5.6 ...
## $ 2018      : num [1:266] 1.59 4.53 5 5.19 5.52 ...
## $ 2019      : num [1:266] 1.49 4.48 4.87 5.12 5.44 ...
## $ 2020      : num [1:266] 1.32 4.42 4.75 5.05 5.37 ...
## $ 2021      : num [1:266] 1.18 4.35 4.64 4.98 5.3 ...
## $ 2022      : logi [1:266] NA NA NA NA NA NA ...

```



```
summary(fertility_rates) # Statistical summary of data. Mainly for numerics
```

```
## Country Name      Country Code      1960      1961
## Length:266      Length:266      Min.   :1.940 Min.   :1.940
## Class :character Class :character 1st Qu.:4.240 1st Qu.:4.082
## Mode  :character Mode  :character Median :6.078 Median :6.083
##                                     Mean  :5.444 Mean  :5.423
##                                     3rd Qu.:6.721 3rd Qu.:6.725
##                                     Max.   :8.234 Max.   :8.266
##                                     NA's   :13    NA's   :14
##      1962      1963      1964      1965
## Min.   :1.790 Min.   :1.820 Min.   :1.790 Min.   :1.740
## 1st Qu.:4.190 1st Qu.:4.160 1st Qu.:4.059 1st Qu.:3.842
## Median :6.085 Median :6.147 Median :6.019 Median :5.960
## Mean   :5.456 Mean   :5.488 Mean   :5.426 Mean   :5.381
## 3rd Qu.:6.747 3rd Qu.:6.771 3rd Qu.:6.734 3rd Qu.:6.733
## Max.   :8.285 Max.   :8.309 Max.   :8.330 Max.   :8.344
## NA's   :13    NA's   :14    NA's   :13    NA's   :13
##      1966      1967      1968      1969
## Min.   :1.580 Min.   :1.800 Min.   :1.830 Min.   :1.870
## 1st Qu.:3.709 1st Qu.:3.637 1st Qu.:3.460 1st Qu.:3.284
## Median :5.907 Median :5.825 Median :5.788 Median :5.738
## Mean   :5.323 Mean   :5.269 Mean   :5.227 Mean   :5.173
## 3rd Qu.:6.707 3rd Qu.:6.683 3rd Qu.:6.682 3rd Qu.:6.679
## Max.   :8.356 Max.   :8.340 Max.   :8.315 Max.   :8.264
## NA's   :13    NA's   :13    NA's   :13    NA's   :13
##      1970      1971      1972      1973
## Min.   :1.823 Min.   :1.680 Min.   :1.580 Min.   :1.490
## 1st Qu.:3.188 1st Qu.:3.144 1st Qu.:3.060 1st Qu.:2.933
## Median :5.636 Median :5.534 Median :5.314 Median :5.252
## Mean   :5.115 Mean   :5.057 Mean   :4.987 Mean   :4.903
## 3rd Qu.:6.680 3rd Qu.:6.654 3rd Qu.:6.599 3rd Qu.:6.630
## Max.   :8.238 Max.   :8.264 Max.   :8.299 Max.   :8.304
## NA's   :12    NA's   :12    NA's   :12    NA's   :12
##      1974      1975      1976      1977
## Min.   :1.510 Min.   :1.450 Min.   :1.450 Min.   :1.400
## 1st Qu.:2.889 1st Qu.:2.760 1st Qu.:2.731 1st Qu.:2.659
## Median :5.086 Median :4.975 Median :4.810 Median :4.706
## Mean   :4.831 Mean   :4.742 Mean   :4.678 Mean   :4.610
## 3rd Qu.:6.608 3rd Qu.:6.586 3rd Qu.:6.554 3rd Qu.:6.512
## Max.   :8.335 Max.   :8.401 Max.   :8.444 Max.   :8.504
## NA's   :12    NA's   :11    NA's   :10    NA's   :11
##      1978      1979      1980      1981
## Min.   :1.380 Min.   :1.380 Min.   :1.440 Min.   :1.430
## 1st Qu.:2.577 1st Qu.:2.554 1st Qu.:2.471 1st Qu.:2.423
## Median :4.534 Median :4.493 Median :4.426 Median :4.314
## Mean   :4.555 Mean   :4.522 Mean   :4.479 Mean   :4.425
## 3rd Qu.:6.474 3rd Qu.:6.463 3rd Qu.:6.399 3rd Qu.:6.375
## Max.   :8.520 Max.   :8.671 Max.   :8.710 Max.   :8.752
## NA's   :11    NA's   :11    NA's   :11    NA's   :11
##      1982      1983      1984      1985
## Min.   :1.410 Min.   :1.330 Min.   :1.290 Min.   :1.370
## 1st Qu.:2.384 1st Qu.:2.373 1st Qu.:2.340 1st Qu.:2.324
## Median :4.216 Median :4.095 Median :4.014 Median :3.959
## Mean   :4.381 Mean   :4.326 Mean   :4.270 Mean   :4.216
## 3rd Qu.:6.371 3rd Qu.:6.303 3rd Qu.:6.229 3rd Qu.:6.138
## Max.   :8.793 Max.   :8.828 Max.   :8.853 Max.   :8.864
## NA's   :10    NA's   :11    NA's   :11    NA's   :11
```

##	1986	1987	1988	1989
##	Min. :1.350	Min. :1.311	Min. :1.360	Min. :1.296
##	1st Qu.:2.321	1st Qu.:2.288	1st Qu.:2.280	1st Qu.:2.244
##	Median :3.962	Median :3.788	Median :3.711	Median :3.583
##	Mean :4.164	Mean :4.103	Mean :4.050	Mean :3.983
##	3rd Qu.:6.018	3rd Qu.:5.856	3rd Qu.:5.798	3rd Qu.:5.692
##	Max. :8.858	Max. :8.833	Max. :8.786	Max. :8.713
##	NA's :11	NA's :10	NA's :11	NA's :11
##	1990	1991	1992	1993
##	Min. :1.272	Min. :1.281	Min. :1.290	Min. :1.250
##	1st Qu.:2.304	1st Qu.:2.187	1st Qu.:2.120	1st Qu.:2.034
##	Median :3.471	Median :3.402	Median :3.318	Median :3.208
##	Mean :3.931	Mean :3.853	Mean :3.776	Mean :3.699
##	3rd Qu.:5.604	3rd Qu.:5.474	3rd Qu.:5.314	3rd Qu.:5.203
##	Max. :8.606	Max. :8.459	Max. :8.272	Max. :8.048
##	NA's :9	NA's :10	NA's :9	NA's :10
##	1994	1995	1996	1997
##	Min. :1.190	Min. :1.160	Min. :1.140	Min. :1.090
##	1st Qu.:1.987	1st Qu.:1.967	1st Qu.:1.931	1st Qu.:1.896
##	Median :3.121	Median :3.072	Median :3.014	Median :2.940
##	Mean :3.623	Mean :3.543	Mean :3.476	Mean :3.408
##	3rd Qu.:5.046	3rd Qu.:4.884	3rd Qu.:4.771	3rd Qu.:4.660
##	Max. :7.989	Max. :7.962	Max. :7.985	Max. :7.965
##	NA's :10	NA's :9	NA's :10	NA's :9
##	1998	1999	2000	2001
##	Min. :1.016	Min. :0.981	Min. :0.912	Min. :0.840
##	1st Qu.:1.860	1st Qu.:1.817	1st Qu.:1.855	1st Qu.:1.800
##	Median :2.815	Median :2.767	Median :2.716	Median :2.667
##	Mean :3.339	Mean :3.288	Mean :3.235	Mean :3.182
##	3rd Qu.:4.576	3rd Qu.:4.516	3rd Qu.:4.434	3rd Qu.:4.375
##	Max. :7.817	Max. :7.752	Max. :7.732	Max. :7.695
##	NA's :9	NA's :9	NA's :7	NA's :8
##	2002	2003	2004	2005
##	Min. :0.800	Min. :0.792	Min. :0.800	Min. :0.834
##	1st Qu.:1.790	1st Qu.:1.786	1st Qu.:1.781	1st Qu.:1.786
##	Median :2.623	Median :2.583	Median :2.582	Median :2.552
##	Mean :3.136	Mean :3.095	Mean :3.068	Mean :3.033
##	3rd Qu.:4.304	3rd Qu.:4.234	3rd Qu.:4.129	3rd Qu.:3.983
##	Max. :7.671	Max. :7.654	Max. :7.634	Max. :7.615
##	NA's :8	NA's :8	NA's :8	NA's :7
##	2006	2007	2008	2009
##	Min. :0.874	Min. :0.918	Min. :0.947	Min. :0.986
##	1st Qu.:1.793	1st Qu.:1.823	1st Qu.:1.838	1st Qu.:1.823
##	Median :2.503	Median :2.510	Median :2.481	Median :2.437
##	Mean :3.007	Mean :2.991	Mean :2.983	Mean :2.957
##	3rd Qu.:3.850	3rd Qu.:3.863	3rd Qu.:3.877	3rd Qu.:3.865
##	Max. :7.579	Max. :7.559	Max. :7.539	Max. :7.513
##	NA's :7	NA's :7	NA's :7	NA's :7
##	2010	2011	2012	2013
##	Min. :1.042	Min. :1.115	Min. :1.103	Min. :1.080
##	1st Qu.:1.802	1st Qu.:1.781	1st Qu.:1.792	1st Qu.:1.750
##	Median :2.397	Median :2.334	Median :2.312	Median :2.328
##	Mean :2.924	Mean :2.895	Mean :2.868	Mean :2.835
##	3rd Qu.:3.880	3rd Qu.:3.836	3rd Qu.:3.753	3rd Qu.:3.688
##	Max. :7.485	Max. :7.449	Max. :7.400	Max. :7.344
##	NA's :7	NA's :8	NA's :6	NA's :8
##	2014	2015	2016	2017
##	Min. :1.205	Min. :1.186	Min. :0.987	Min. :0.872

```
## 1st Qu.:1.751 1st Qu.:1.734 1st Qu.:1.725 1st Qu.:1.693
## Median :2.300 Median :2.260 Median :2.245 Median :2.211
## Mean :2.813 Mean :2.775 Mean :2.742 Mean :2.694
## 3rd Qu.:3.632 3rd Qu.:3.560 3rd Qu.:3.492 3rd Qu.:3.432
## Max. :7.279 Max. :7.211 Max. :7.141 Max. :7.084
## NA's :8 NA's :7 NA's :8 NA's :8
## 2018 2019 2020 2021 2022
## Min. :0.917 Min. :0.918 Min. :0.837 Min. :0.772 Mode:logical
## 1st Qu.:1.648 1st Qu.:1.612 1st Qu.:1.572 1st Qu.:1.583 NA's:266
## Median :2.175 Median :2.139 Median :2.103 Median :2.088
## Mean :2.653 Mean :2.611 Mean :2.560 Mean :2.542
## 3rd Qu.:3.403 3rd Qu.:3.333 3rd Qu.:3.271 3rd Qu.:3.288
## Max. :7.023 Max. :6.961 Max. :6.892 Max. :6.820
## NA's :8 NA's :8 NA's :7 NA's :8
```

Step 4: Conduct descriptive analysis

```
# Compare total fertility rates in 1960 vs. total fertility rates in 2021
aggregate(fertility_rates$"1960" ~ fertility_rates$"2021", FUN = mean)
```

```
## fertility_rates$"2021" fertility_rates$"1960"
## 1 0.772000 5.067000
## 2 0.808000 5.949000
## 3 0.907000 4.796000
## 4 1.005000 5.162000
## 5 1.088000 4.933000
## 6 1.120000 5.760000
## 7 1.140000 3.620000
## 8 1.160000 2.240000
## 9 1.164000 4.451000
## 10 1.180000 4.820000
## 11 1.190000 2.860000
## 12 1.250000 2.400000
## 13 1.300000 2.755000
## 14 1.321000 3.512000
## 15 1.330000 2.980000
## 16 1.331000 6.248000
## 17 1.340000 2.560000
## 18 1.350000 3.907000
## 19 1.352000 5.580000
## 20 1.380000 2.725000
## 21 1.383908 4.801000
## 22 1.389000 4.818000
## 23 1.390000 4.342500
## 24 1.396865 4.378614
## 25 1.399000 6.967000
## 26 1.410000 6.167000
## 27 1.413000 6.704000
## 28 1.430000 3.811000
## 29 1.442000 4.129000
## 30 1.457000 2.270000
## 31 1.460000 4.719000
## 32 1.480000 2.401500
## 33 1.483000 2.670000
## 34 1.488552 2.897990
## 35 1.489433 4.561606
## 36 1.493000 2.673500
## 37 1.498219 4.531774
```

## 38	1.504510	2.605864
## 39	1.516846	4.864229
## 40	1.520000	4.159000
## 41	1.520288	2.571186
## 42	1.520442	4.841982
## 43	1.522000	6.359000
## 44	1.531000	7.169000
## 45	1.533000	6.712000
## 46	1.537000	4.697000
## 47	1.544788	3.019437
## 48	1.550000	2.850000
## 49	1.550993	2.491059
## 50	1.560000	2.690000
## 51	1.564000	2.875000
## 52	1.570000	1.940000
## 53	1.575000	4.786000
## 54	1.580000	3.094000
## 55	1.581000	4.202000
## 56	1.589351	3.285589
## 57	1.590000	2.020000
## 58	1.595000	6.866000
## 59	1.600000	3.253500
## 60	1.610000	1.980000
## 61	1.620000	2.676000
## 62	1.626000	5.345000
## 63	1.633000	4.333000
## 64	1.640000	3.155000
## 65	1.640018	3.668255
## 66	1.641000	6.061000
## 67	1.664000	3.654000
## 68	1.664522	5.727913
## 69	1.669000	5.790000
## 70	1.670000	2.170000
## 71	1.692000	7.052500
## 72	1.693061	2.831429
## 73	1.699000	5.888000
## 74	1.700000	3.453000
## 75	1.717000	6.735000
## 76	1.720000	3.175000
## 77	1.750000	3.498000
## 78	1.778000	6.836000
## 79	1.797000	7.286000
## 80	1.800000	2.340000
## 81	1.801000	6.647000
## 82	1.803000	6.520500
## 83	1.806000	3.328000
## 84	1.809000	3.568000
## 85	1.811000	7.152000
## 86	1.820000	4.290000
## 87	1.822000	6.763000
## 88	1.824446	4.970095
## 89	1.830000	2.470000
## 90	1.835001	3.103683
## 91	1.848000	3.012000
## 92	1.852014	5.959449
## 93	1.853283	5.865889
## 94	1.864022	5.945441
## 95	1.883205	3.184230

## 96	1.885000	3.075000
## 97	1.889000	6.383000
## 98	1.896000	6.885000
## 99	1.944000	6.280000
## 100	1.981000	6.784000
## 101	1.990000	5.465000
## 102	2.004000	6.743000
## 103	2.010000	5.972500
## 104	2.020000	6.278000
## 105	2.026000	6.721000
## 106	2.029000	6.030000
## 107	2.031000	5.921000
## 108	2.081000	2.942000
## 109	2.086000	6.942000
## 110	2.091000	5.818000
## 111	2.110000	7.162000
## 112	2.136727	5.219097
## 113	2.151000	5.983000
## 114	2.175000	5.547000
## 115	2.192000	6.941000
## 116	2.211000	6.358000
## 117	2.240930	6.078350
## 118	2.273000	7.555000
## 119	2.273169	4.695876
## 120	2.321000	7.159000
## 121	2.325000	5.844000
## 122	2.328000	7.040000
## 123	2.344000	6.251000
## 124	2.348000	6.608000
## 125	2.350962	6.166562
## 126	2.363000	7.458000
## 127	2.374000	6.159000
## 128	2.384585	5.251170
## 129	2.393171	5.301390
## 130	2.395000	6.955000
## 131	2.397000	6.372000
## 132	2.415000	5.948000
## 133	2.427000	7.626000
## 134	2.462000	7.373000
## 135	2.469000	6.500000
## 136	2.475000	6.461000
## 137	2.496000	6.292000
## 138	2.569000	5.906000
## 139	2.578281	5.983878
## 140	2.618000	6.358000
## 141	2.623000	7.247000
## 142	2.629064	6.950247
## 143	2.655901	5.357909
## 144	2.660823	7.002555
## 145	2.667000	6.590000
## 146	2.670537	7.002555
## 147	2.711000	6.686000
## 148	2.729000	8.234000
## 149	2.747000	7.485000
## 150	2.748000	7.148000
## 151	2.791000	6.628000
## 152	2.804000	6.828000
## 153	2.814000	6.208000

## 154	2.830000	7.669000
## 155	2.837000	6.827000
## 156	2.839000	6.752000
## 157	2.859614	5.069770
## 158	2.889000	7.503000
## 159	2.890000	5.376000
## 160	2.917000	6.794000
## 161	3.000000	3.866000
## 162	3.018000	5.819000
## 163	3.142565	6.934332
## 164	3.149000	6.319000
## 165	3.163000	4.778000
## 166	3.173000	6.613000
## 167	3.186000	6.547000
## 168	3.215000	6.018000
## 169	3.237000	6.885000
## 170	3.241013	6.768236
## 171	3.303000	6.205000
## 172	3.304000	6.553000
## 173	3.320000	4.530000
## 174	3.335000	7.632000
## 175	3.470000	6.800000
## 176	3.491000	5.821000
## 177	3.496000	5.300000
## 178	3.519000	5.269000
## 179	3.563000	6.847000
## 180	3.735000	6.863000
## 181	3.795000	7.938000
## 182	3.821000	8.187000
## 183	3.823000	6.242000
## 184	3.843961	6.629390
## 185	3.851000	7.300000
## 186	3.867000	6.483000
## 187	3.917000	7.029000
## 188	3.921027	6.622652
## 189	3.930000	7.646000
## 190	3.978000	6.483500
## 191	3.983000	6.970000
## 192	3.983665	6.640794
## 193	4.005000	5.921000
## 194	4.080936	6.607081
## 195	4.089000	6.391000
## 196	4.159000	6.880000
## 197	4.171000	6.085000
## 198	4.257000	6.717000
## 199	4.266000	5.653000
## 200	4.308000	7.115000
## 201	4.354710	6.724125
## 202	4.359060	5.603609
## 203	4.387000	6.996000
## 204	4.398000	6.354000
## 205	4.399000	6.112000
## 206	4.418000	7.691000
## 207	4.457000	6.647000
## 208	4.463000	5.647000
## 209	4.469000	6.721000
## 210	4.585000	6.936000
## 211	4.601289	6.609096

## 212	4.601463	6.609096
## 213	4.620300	6.702820
## 214	4.643000	7.282000
## 215	4.644000	6.315000
## 216	4.644854	6.414706
## 217	4.684000	6.246000
## 218	4.726000	6.725000
## 219	4.772000	6.248000
## 220	4.844171	6.563645
## 221	4.973000	6.282000
## 222	4.978662	6.458448
## 223	5.078000	7.003000
## 224	5.237000	6.364000
## 225	5.304000	6.708000
## 226	5.956000	7.004000
## 227	5.978000	5.814000
## 228	6.156000	6.080000
## 229	6.255000	6.250000
## 230	6.312000	7.250000
## 231	6.820000	7.530000

```
# Compare median fertility rates in 1960 vs. median fertility in 2021
aggregate(fertility_rates$"1960" ~ fertility_rates$"2021", FUN = median)
```

##	fertility_rates\$"2021"	fertility_rates\$"1960"
## 1	0.772000	5.067000
## 2	0.808000	5.949000
## 3	0.907000	4.796000
## 4	1.005000	5.162000
## 5	1.088000	4.933000
## 6	1.120000	5.760000
## 7	1.140000	3.620000
## 8	1.160000	2.240000
## 9	1.164000	4.451000
## 10	1.180000	4.820000
## 11	1.190000	2.860000
## 12	1.250000	2.400000
## 13	1.300000	2.755000
## 14	1.321000	3.512000
## 15	1.330000	2.980000
## 16	1.331000	6.248000
## 17	1.340000	2.560000
## 18	1.350000	3.907000
## 19	1.352000	5.580000
## 20	1.380000	2.725000
## 21	1.383908	4.801000
## 22	1.389000	4.818000
## 23	1.390000	4.342500
## 24	1.396865	4.378614
## 25	1.399000	6.967000
## 26	1.410000	6.167000
## 27	1.413000	6.704000
## 28	1.430000	3.811000
## 29	1.442000	4.129000
## 30	1.457000	2.270000
## 31	1.460000	4.719000
## 32	1.480000	2.401500
## 33	1.483000	2.670000
## 34	1.488552	2.897990

## 35	1.489433	4.561606
## 36	1.493000	2.673500
## 37	1.498219	4.531774
## 38	1.504510	2.605864
## 39	1.516846	4.864229
## 40	1.520000	4.159000
## 41	1.520288	2.571186
## 42	1.520442	4.841982
## 43	1.522000	6.359000
## 44	1.531000	7.169000
## 45	1.533000	6.712000
## 46	1.537000	4.697000
## 47	1.544788	3.019437
## 48	1.550000	2.850000
## 49	1.550993	2.491059
## 50	1.560000	2.690000
## 51	1.564000	2.875000
## 52	1.570000	1.940000
## 53	1.575000	4.786000
## 54	1.580000	2.370000
## 55	1.581000	4.202000
## 56	1.589351	3.285589
## 57	1.590000	2.020000
## 58	1.595000	6.866000
## 59	1.600000	3.253500
## 60	1.610000	1.980000
## 61	1.620000	2.676000
## 62	1.626000	5.345000
## 63	1.633000	4.333000
## 64	1.640000	3.040000
## 65	1.640018	3.668255
## 66	1.641000	6.061000
## 67	1.664000	3.654000
## 68	1.664522	5.727913
## 69	1.669000	5.790000
## 70	1.670000	2.170000
## 71	1.692000	7.052500
## 72	1.693061	2.831429
## 73	1.699000	5.888000
## 74	1.700000	3.453000
## 75	1.717000	6.735000
## 76	1.720000	3.175000
## 77	1.750000	3.498000
## 78	1.778000	6.836000
## 79	1.797000	7.286000
## 80	1.800000	2.340000
## 81	1.801000	6.647000
## 82	1.803000	6.520500
## 83	1.806000	3.328000
## 84	1.809000	3.568000
## 85	1.811000	7.152000
## 86	1.820000	4.290000
## 87	1.822000	6.763000
## 88	1.824446	4.970095
## 89	1.830000	2.470000
## 90	1.835001	3.103683
## 91	1.848000	3.012000
## 92	1.852014	5.959449

## 93	1.853283	5.865889
## 94	1.864022	5.945441
## 95	1.883205	3.184230
## 96	1.885000	3.075000
## 97	1.889000	6.383000
## 98	1.896000	6.885000
## 99	1.944000	6.280000
## 100	1.981000	6.784000
## 101	1.990000	5.465000
## 102	2.004000	6.743000
## 103	2.010000	5.972500
## 104	2.020000	6.278000
## 105	2.026000	6.721000
## 106	2.029000	6.030000
## 107	2.031000	5.921000
## 108	2.081000	2.942000
## 109	2.086000	6.942000
## 110	2.091000	5.818000
## 111	2.110000	7.162000
## 112	2.136727	5.219097
## 113	2.151000	5.983000
## 114	2.175000	5.547000
## 115	2.192000	6.941000
## 116	2.211000	6.358000
## 117	2.240930	6.078350
## 118	2.273000	7.555000
## 119	2.273169	4.695876
## 120	2.321000	7.159000
## 121	2.325000	5.844000
## 122	2.328000	7.040000
## 123	2.344000	6.251000
## 124	2.348000	6.608000
## 125	2.350962	6.166562
## 126	2.363000	7.458000
## 127	2.374000	6.159000
## 128	2.384585	5.251170
## 129	2.393171	5.301390
## 130	2.395000	6.955000
## 131	2.397000	6.372000
## 132	2.415000	5.948000
## 133	2.427000	7.626000
## 134	2.462000	7.373000
## 135	2.469000	6.500000
## 136	2.475000	6.461000
## 137	2.496000	6.292000
## 138	2.569000	5.906000
## 139	2.578281	5.983878
## 140	2.618000	6.358000
## 141	2.623000	7.247000
## 142	2.629064	6.950247
## 143	2.655901	5.357909
## 144	2.660823	7.002555
## 145	2.667000	6.590000
## 146	2.670537	7.002555
## 147	2.711000	6.686000
## 148	2.729000	8.234000
## 149	2.747000	7.485000
## 150	2.748000	7.148000

## 151	2.791000	6.628000
## 152	2.804000	6.828000
## 153	2.814000	6.208000
## 154	2.830000	7.669000
## 155	2.837000	6.827000
## 156	2.839000	6.752000
## 157	2.859614	5.069770
## 158	2.889000	7.503000
## 159	2.890000	5.376000
## 160	2.917000	6.794000
## 161	3.000000	3.866000
## 162	3.018000	5.819000
## 163	3.142565	6.934332
## 164	3.149000	6.319000
## 165	3.163000	4.778000
## 166	3.173000	6.613000
## 167	3.186000	6.547000
## 168	3.215000	6.018000
## 169	3.237000	6.885000
## 170	3.241013	6.768236
## 171	3.303000	6.205000
## 172	3.304000	6.553000
## 173	3.320000	4.530000
## 174	3.335000	7.632000
## 175	3.470000	6.800000
## 176	3.491000	5.821000
## 177	3.496000	5.300000
## 178	3.519000	5.269000
## 179	3.563000	6.847000
## 180	3.735000	6.863000
## 181	3.795000	7.938000
## 182	3.821000	8.187000
## 183	3.823000	6.242000
## 184	3.843961	6.629390
## 185	3.851000	7.300000
## 186	3.867000	6.483000
## 187	3.917000	7.029000
## 188	3.921027	6.622652
## 189	3.930000	7.646000
## 190	3.978000	6.483500
## 191	3.983000	6.970000
## 192	3.983665	6.640794
## 193	4.005000	5.921000
## 194	4.080936	6.607081
## 195	4.089000	6.391000
## 196	4.159000	6.880000
## 197	4.171000	6.085000
## 198	4.257000	6.717000
## 199	4.266000	5.653000
## 200	4.308000	7.115000
## 201	4.354710	6.724125
## 202	4.359060	5.603609
## 203	4.387000	6.996000
## 204	4.398000	6.354000
## 205	4.399000	6.112000
## 206	4.418000	7.691000
## 207	4.457000	6.647000
## 208	4.463000	5.647000

## 209	4.469000	6.721000
## 210	4.585000	6.936000
## 211	4.601289	6.609096
## 212	4.601463	6.609096
## 213	4.620300	6.702820
## 214	4.643000	7.282000
## 215	4.644000	6.315000
## 216	4.644854	6.414706
## 217	4.684000	6.246000
## 218	4.726000	6.725000
## 219	4.772000	6.248000
## 220	4.844171	6.563645
## 221	4.973000	6.282000
## 222	4.978662	6.458448
## 223	5.078000	7.003000
## 224	5.237000	6.364000
## 225	5.304000	6.708000
## 226	5.956000	7.004000
## 227	5.978000	5.814000
## 228	6.156000	6.080000
## 229	6.255000	6.250000
## 230	6.312000	7.250000
## 231	6.820000	7.530000

```
# Compare maximum fertility rates in 1960 vs. maximum fertility rates in 2021
aggregate(fertility_rates$"1960" ~ fertility_rates$"2021", FUN = max)
```

##	fertility_rates\$"2021"	fertility_rates\$"1960"
## 1	0.772000	5.067000
## 2	0.808000	5.949000
## 3	0.907000	4.796000
## 4	1.005000	5.162000
## 5	1.088000	4.933000
## 6	1.120000	5.760000
## 7	1.140000	3.620000
## 8	1.160000	2.240000
## 9	1.164000	4.451000
## 10	1.180000	4.820000
## 11	1.190000	2.860000
## 12	1.250000	2.400000
## 13	1.300000	3.510000
## 14	1.321000	3.512000
## 15	1.330000	2.980000
## 16	1.331000	6.248000
## 17	1.340000	2.560000
## 18	1.350000	3.907000
## 19	1.352000	5.580000
## 20	1.380000	3.160000
## 21	1.383908	4.801000
## 22	1.389000	4.818000
## 23	1.390000	6.455000
## 24	1.396865	4.378614
## 25	1.399000	6.967000
## 26	1.410000	6.167000
## 27	1.413000	6.704000
## 28	1.430000	3.811000
## 29	1.442000	4.129000
## 30	1.457000	2.270000
## 31	1.460000	6.718000

## 32	1.480000	2.690000
## 33	1.483000	2.670000
## 34	1.488552	2.897990
## 35	1.489433	4.561606
## 36	1.493000	2.827000
## 37	1.498219	4.531774
## 38	1.504510	2.605864
## 39	1.516846	4.864229
## 40	1.520000	5.878000
## 41	1.520288	2.571186
## 42	1.520442	4.841982
## 43	1.522000	6.359000
## 44	1.531000	7.169000
## 45	1.533000	6.712000
## 46	1.537000	4.697000
## 47	1.544788	3.019437
## 48	1.550000	2.850000
## 49	1.550993	2.491059
## 50	1.560000	2.690000
## 51	1.564000	2.875000
## 52	1.570000	1.940000
## 53	1.575000	4.786000
## 54	1.580000	4.602000
## 55	1.581000	4.202000
## 56	1.589351	3.285589
## 57	1.590000	2.020000
## 58	1.595000	6.866000
## 59	1.600000	3.967000
## 60	1.610000	1.980000
## 61	1.620000	3.120000
## 62	1.626000	5.345000
## 63	1.633000	4.333000
## 64	1.640000	4.240000
## 65	1.640018	3.668255
## 66	1.641000	6.061000
## 67	1.664000	3.654000
## 68	1.664522	5.727913
## 69	1.669000	5.790000
## 70	1.670000	2.170000
## 71	1.692000	7.301000
## 72	1.693061	2.831429
## 73	1.699000	5.888000
## 74	1.700000	3.453000
## 75	1.717000	6.735000
## 76	1.720000	3.780000
## 77	1.750000	3.498000
## 78	1.778000	6.836000
## 79	1.797000	7.286000
## 80	1.800000	2.340000
## 81	1.801000	6.647000
## 82	1.803000	6.634000
## 83	1.806000	3.328000
## 84	1.809000	3.568000
## 85	1.811000	7.152000
## 86	1.820000	4.290000
## 87	1.822000	6.763000
## 88	1.824446	4.970095
## 89	1.830000	2.850000

## 90	1.835001	3.103683
## 91	1.848000	3.012000
## 92	1.852014	5.959449
## 93	1.853283	5.865889
## 94	1.864022	5.945441
## 95	1.883205	3.184230
## 96	1.885000	3.075000
## 97	1.889000	6.383000
## 98	1.896000	6.885000
## 99	1.944000	6.280000
## 100	1.981000	6.784000
## 101	1.990000	5.465000
## 102	2.004000	6.743000
## 103	2.010000	6.500000
## 104	2.020000	6.278000
## 105	2.026000	6.721000
## 106	2.029000	6.030000
## 107	2.031000	5.921000
## 108	2.081000	2.942000
## 109	2.086000	6.942000
## 110	2.091000	5.818000
## 111	2.110000	7.162000
## 112	2.136727	5.219097
## 113	2.151000	5.983000
## 114	2.175000	5.547000
## 115	2.192000	6.941000
## 116	2.211000	6.358000
## 117	2.240930	6.078350
## 118	2.273000	7.555000
## 119	2.273169	4.695876
## 120	2.321000	7.159000
## 121	2.325000	5.844000
## 122	2.328000	7.040000
## 123	2.344000	6.251000
## 124	2.348000	6.608000
## 125	2.350962	6.166562
## 126	2.363000	7.458000
## 127	2.374000	6.159000
## 128	2.384585	5.251170
## 129	2.393171	5.301390
## 130	2.395000	6.955000
## 131	2.397000	6.372000
## 132	2.415000	5.948000
## 133	2.427000	7.626000
## 134	2.462000	7.373000
## 135	2.469000	6.500000
## 136	2.475000	6.461000
## 137	2.496000	6.292000
## 138	2.569000	5.906000
## 139	2.578281	5.983878
## 140	2.618000	6.358000
## 141	2.623000	7.247000
## 142	2.629064	6.950247
## 143	2.655901	5.357909
## 144	2.660823	7.002555
## 145	2.667000	6.590000
## 146	2.670537	7.002555
## 147	2.711000	6.686000

## 148	2.729000	8.234000
## 149	2.747000	7.485000
## 150	2.748000	7.148000
## 151	2.791000	6.628000
## 152	2.804000	6.828000
## 153	2.814000	6.208000
## 154	2.830000	7.669000
## 155	2.837000	6.827000
## 156	2.839000	6.752000
## 157	2.859614	5.069770
## 158	2.889000	7.503000
## 159	2.890000	5.376000
## 160	2.917000	6.794000
## 161	3.000000	3.866000
## 162	3.018000	5.819000
## 163	3.142565	6.934332
## 164	3.149000	6.319000
## 165	3.163000	4.778000
## 166	3.173000	6.613000
## 167	3.186000	6.547000
## 168	3.215000	6.018000
## 169	3.237000	6.885000
## 170	3.241013	6.768236
## 171	3.303000	6.205000
## 172	3.304000	6.553000
## 173	3.320000	4.530000
## 174	3.335000	7.632000
## 175	3.470000	6.800000
## 176	3.491000	7.220000
## 177	3.496000	5.300000
## 178	3.519000	5.269000
## 179	3.563000	6.847000
## 180	3.735000	6.863000
## 181	3.795000	7.938000
## 182	3.821000	8.187000
## 183	3.823000	6.242000
## 184	3.843961	6.629390
## 185	3.851000	7.300000
## 186	3.867000	6.483000
## 187	3.917000	7.029000
## 188	3.921027	6.622652
## 189	3.930000	7.646000
## 190	3.978000	6.792000
## 191	3.983000	6.970000
## 192	3.983665	6.640794
## 193	4.005000	5.921000
## 194	4.080936	6.607081
## 195	4.089000	6.391000
## 196	4.159000	6.880000
## 197	4.171000	6.085000
## 198	4.257000	6.717000
## 199	4.266000	5.653000
## 200	4.308000	7.115000
## 201	4.354710	6.724125
## 202	4.359060	5.603609
## 203	4.387000	6.996000
## 204	4.398000	6.354000
## 205	4.399000	6.112000

## 206	4.418000	7.691000
## 207	4.457000	6.647000
## 208	4.463000	5.647000
## 209	4.469000	6.721000
## 210	4.585000	6.936000
## 211	4.601289	6.609096
## 212	4.601463	6.609096
## 213	4.620300	6.702820
## 214	4.643000	7.282000
## 215	4.644000	6.315000
## 216	4.644854	6.414706
## 217	4.684000	6.246000
## 218	4.726000	6.725000
## 219	4.772000	6.248000
## 220	4.844171	6.563645
## 221	4.973000	6.282000
## 222	4.978662	6.458448
## 223	5.078000	7.003000
## 224	5.237000	6.364000
## 225	5.304000	6.708000
## 226	5.956000	7.004000
## 227	5.978000	5.814000
## 228	6.156000	6.080000
## 229	6.255000	6.250000
## 230	6.312000	7.250000
## 231	6.820000	7.530000

```
# Compare minimum fertility rates in 1960 vs. minimum fertility rates in 2021
aggregate(fertility_rates$"1960" ~ fertility_rates$"2021", FUN = min)
```

##	fertility_rates\$"2021"	fertility_rates\$"1960"
## 1	0.772000	5.067000
## 2	0.808000	5.949000
## 3	0.907000	4.796000
## 4	1.005000	5.162000
## 5	1.088000	4.933000
## 6	1.120000	5.760000
## 7	1.140000	3.620000
## 8	1.160000	2.240000
## 9	1.164000	4.451000
## 10	1.180000	4.820000
## 11	1.190000	2.860000
## 12	1.250000	2.400000
## 13	1.300000	2.000000
## 14	1.321000	3.512000
## 15	1.330000	2.980000
## 16	1.331000	6.248000
## 17	1.340000	2.560000
## 18	1.350000	3.907000
## 19	1.352000	5.580000
## 20	1.380000	2.290000
## 21	1.383908	4.801000
## 22	1.389000	4.818000
## 23	1.390000	2.230000
## 24	1.396865	4.378614
## 25	1.399000	6.967000
## 26	1.410000	6.167000
## 27	1.413000	6.704000
## 28	1.430000	3.811000

## 29	1.442000	4.129000
## 30	1.457000	2.270000
## 31	1.460000	2.720000
## 32	1.480000	2.113000
## 33	1.483000	2.670000
## 34	1.488552	2.897990
## 35	1.489433	4.561606
## 36	1.493000	2.520000
## 37	1.498219	4.531774
## 38	1.504510	2.605864
## 39	1.516846	4.864229
## 40	1.520000	2.440000
## 41	1.520288	2.571186
## 42	1.520442	4.841982
## 43	1.522000	6.359000
## 44	1.531000	7.169000
## 45	1.533000	6.712000
## 46	1.537000	4.697000
## 47	1.544788	3.019437
## 48	1.550000	2.850000
## 49	1.550993	2.491059
## 50	1.560000	2.690000
## 51	1.564000	2.875000
## 52	1.570000	1.940000
## 53	1.575000	4.786000
## 54	1.580000	2.310000
## 55	1.581000	4.202000
## 56	1.589351	3.285589
## 57	1.590000	2.020000
## 58	1.595000	6.866000
## 59	1.600000	2.540000
## 60	1.610000	1.980000
## 61	1.620000	2.232000
## 62	1.626000	5.345000
## 63	1.633000	4.333000
## 64	1.640000	2.185000
## 65	1.640018	3.668255
## 66	1.641000	6.061000
## 67	1.664000	3.654000
## 68	1.664522	5.727913
## 69	1.669000	5.790000
## 70	1.670000	2.170000
## 71	1.692000	6.804000
## 72	1.693061	2.831429
## 73	1.699000	5.888000
## 74	1.700000	3.453000
## 75	1.717000	6.735000
## 76	1.720000	2.570000
## 77	1.750000	3.498000
## 78	1.778000	6.836000
## 79	1.797000	7.286000
## 80	1.800000	2.340000
## 81	1.801000	6.647000
## 82	1.803000	6.407000
## 83	1.806000	3.328000
## 84	1.809000	3.568000
## 85	1.811000	7.152000
## 86	1.820000	4.290000

## 87	1.822000	6.763000
## 88	1.824446	4.970095
## 89	1.830000	2.090000
## 90	1.835001	3.103683
## 91	1.848000	3.012000
## 92	1.852014	5.959449
## 93	1.853283	5.865889
## 94	1.864022	5.945441
## 95	1.883205	3.184230
## 96	1.885000	3.075000
## 97	1.889000	6.383000
## 98	1.896000	6.885000
## 99	1.944000	6.280000
## 100	1.981000	6.784000
## 101	1.990000	5.465000
## 102	2.004000	6.743000
## 103	2.010000	5.445000
## 104	2.020000	6.278000
## 105	2.026000	6.721000
## 106	2.029000	6.030000
## 107	2.031000	5.921000
## 108	2.081000	2.942000
## 109	2.086000	6.942000
## 110	2.091000	5.818000
## 111	2.110000	7.162000
## 112	2.136727	5.219097
## 113	2.151000	5.983000
## 114	2.175000	5.547000
## 115	2.192000	6.941000
## 116	2.211000	6.358000
## 117	2.240930	6.078350
## 118	2.273000	7.555000
## 119	2.273169	4.695876
## 120	2.321000	7.159000
## 121	2.325000	5.844000
## 122	2.328000	7.040000
## 123	2.344000	6.251000
## 124	2.348000	6.608000
## 125	2.350962	6.166562
## 126	2.363000	7.458000
## 127	2.374000	6.159000
## 128	2.384585	5.251170
## 129	2.393171	5.301390
## 130	2.395000	6.955000
## 131	2.397000	6.372000
## 132	2.415000	5.948000
## 133	2.427000	7.626000
## 134	2.462000	7.373000
## 135	2.469000	6.500000
## 136	2.475000	6.461000
## 137	2.496000	6.292000
## 138	2.569000	5.906000
## 139	2.578281	5.983878
## 140	2.618000	6.358000
## 141	2.623000	7.247000
## 142	2.629064	6.950247
## 143	2.655901	5.357909
## 144	2.660823	7.002555

## 145	2.667000	6.590000
## 146	2.670537	7.002555
## 147	2.711000	6.686000
## 148	2.729000	8.234000
## 149	2.747000	7.485000
## 150	2.748000	7.148000
## 151	2.791000	6.628000
## 152	2.804000	6.828000
## 153	2.814000	6.208000
## 154	2.830000	7.669000
## 155	2.837000	6.827000
## 156	2.839000	6.752000
## 157	2.859614	5.069770
## 158	2.889000	7.503000
## 159	2.890000	5.376000
## 160	2.917000	6.794000
## 161	3.000000	3.866000
## 162	3.018000	5.819000
## 163	3.142565	6.934332
## 164	3.149000	6.319000
## 165	3.163000	4.778000
## 166	3.173000	6.613000
## 167	3.186000	6.547000
## 168	3.215000	6.018000
## 169	3.237000	6.885000
## 170	3.241013	6.768236
## 171	3.303000	6.205000
## 172	3.304000	6.553000
## 173	3.320000	4.530000
## 174	3.335000	7.632000
## 175	3.470000	6.800000
## 176	3.491000	4.422000
## 177	3.496000	5.300000
## 178	3.519000	5.269000
## 179	3.563000	6.847000
## 180	3.735000	6.863000
## 181	3.795000	7.938000
## 182	3.821000	8.187000
## 183	3.823000	6.242000
## 184	3.843961	6.629390
## 185	3.851000	7.300000
## 186	3.867000	6.483000
## 187	3.917000	7.029000
## 188	3.921027	6.622652
## 189	3.930000	7.646000
## 190	3.978000	6.175000
## 191	3.983000	6.970000
## 192	3.983665	6.640794
## 193	4.005000	5.921000
## 194	4.080936	6.607081
## 195	4.089000	6.391000
## 196	4.159000	6.880000
## 197	4.171000	6.085000
## 198	4.257000	6.717000
## 199	4.266000	5.653000
## 200	4.308000	7.115000
## 201	4.354710	6.724125
## 202	4.359060	5.603609

```
## 203      4.387000      6.996000
## 204      4.398000      6.354000
## 205      4.399000      6.112000
## 206      4.418000      7.691000
## 207      4.457000      6.647000
## 208      4.463000      5.647000
## 209      4.469000      6.721000
## 210      4.585000      6.936000
## 211      4.601289      6.609096
## 212      4.601463      6.609096
## 213      4.620300      6.702820
## 214      4.643000      7.282000
## 215      4.644000      6.315000
## 216      4.644854      6.414706
## 217      4.684000      6.246000
## 218      4.726000      6.725000
## 219      4.772000      6.248000
## 220      4.844171      6.563645
## 221      4.973000      6.282000
## 222      4.978662      6.458448
## 223      5.078000      7.003000
## 224      5.237000      6.364000
## 225      5.304000      6.708000
## 226      5.956000      7.004000
## 227      5.978000      5.814000
## 228      6.156000      6.080000
## 229      6.255000      6.250000
## 230      6.312000      7.250000
## 231      6.820000      7.530000
```

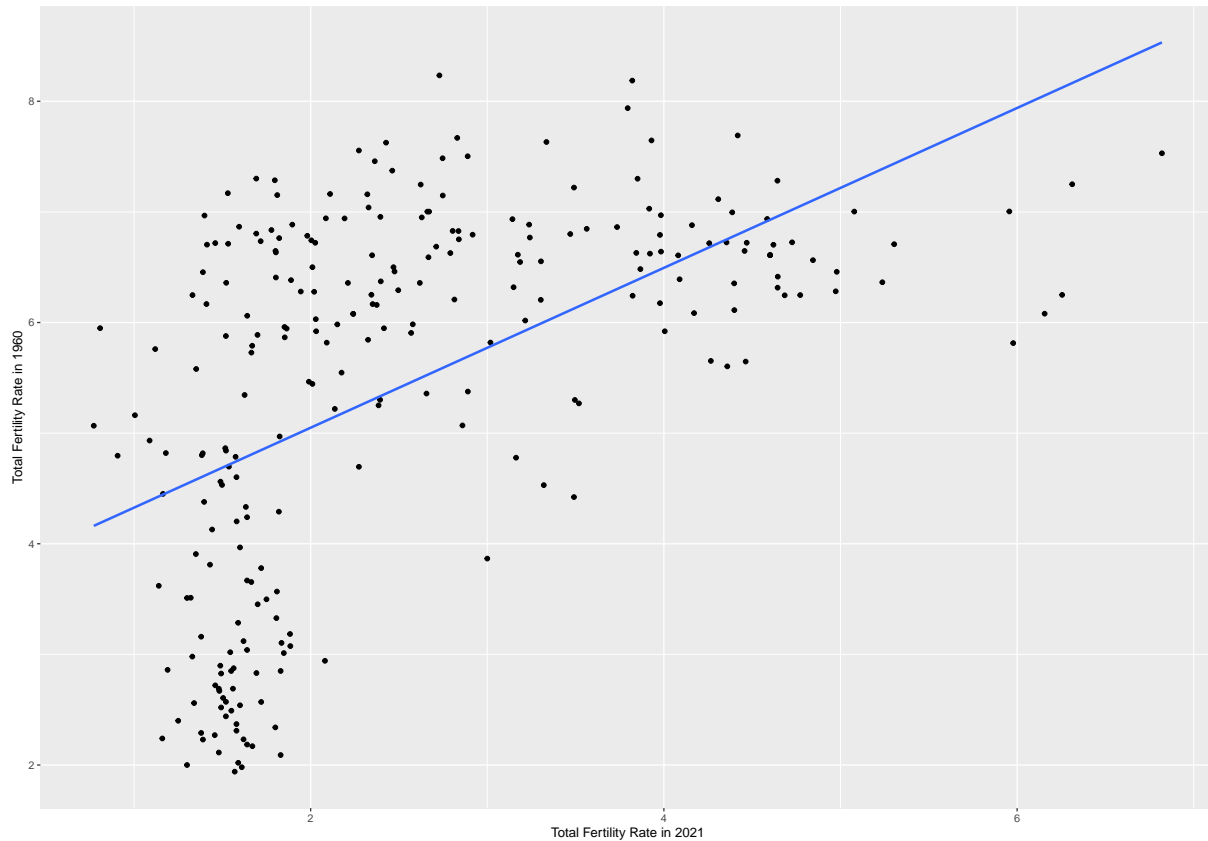
```
# Find Total Fertility rate by Country Name in 1960 vs. 2021.
# Assign the result to avg_fertility_rate.
avg_fertility_rate <- aggregate(fertility_rates$"1960"
                               ~ fertility_rates$"2021"
                               + fertility_rates$"Country Name",
                               FUN = mean)
```

Step 5: Create figures

```
# Figure 1: Total Fertility Rate by Country (1960 vs. 2021)
ggplot(avg_fertility_rate, aes(x = `fertility_rates$"2021"`, y = `fertility_rates$"1960"`) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  xlab("Total Fertility Rate in 2021") +
  ylab("Total Fertility Rate in 1960") +
  ggtitle("Figure 1. Total Fertility Rate by Country (1960 vs. 2021)")

## `geom_smooth()` using formula = 'y ~ x'
```

Figure 1. Total Fertility Rate by Country (1960 vs. 2021)



Each data point in Figure 1 represents a different country. These data points suggest that there has been a considerable decrease in total fertility rates from 1960 to 2021. Let's now take a look at this trend on a region-by-region basis.

```
# Find unique country names in fertility_rates table
country_names <- unique(fertility_rates$`Country Name`)
sorted_country_names <- sort(country_names)
sorted_country_names
```

```
## [1] "Afghanistan"
## [2] "Africa Eastern and Southern"
## [3] "Africa Western and Central"
## [4] "Albania"
## [5] "Algeria"
## [6] "American Samoa"
## [7] "Andorra"
## [8] "Angola"
## [9] "Antigua and Barbuda"
## [10] "Arab World"
## [11] "Argentina"
## [12] "Armenia"
## [13] "Aruba"
## [14] "Australia"
## [15] "Austria"
## [16] "Azerbaijan"
## [17] "Bahamas, The"
## [18] "Bahrain"
## [19] "Bangladesh"
## [20] "Barbados"
## [21] "Belarus"
## [22] "Belgium"
```

[23] "Belize"
 ## [24] "Benin"
 ## [25] "Bermuda"
 ## [26] "Bhutan"
 ## [27] "Bolivia"
 ## [28] "Bosnia and Herzegovina"
 ## [29] "Botswana"
 ## [30] "Brazil"
 ## [31] "British Virgin Islands"
 ## [32] "Brunei Darussalam"
 ## [33] "Bulgaria"
 ## [34] "Burkina Faso"
 ## [35] "Burundi"
 ## [36] "Cabo Verde"
 ## [37] "Cambodia"
 ## [38] "Cameroon"
 ## [39] "Canada"
 ## [40] "Caribbean small states"
 ## [41] "Cayman Islands"
 ## [42] "Central African Republic"
 ## [43] "Central Europe and the Baltics"
 ## [44] "Chad"
 ## [45] "Channel Islands"
 ## [46] "Chile"
 ## [47] "China"
 ## [48] "Colombia"
 ## [49] "Comoros"
 ## [50] "Congo, Dem. Rep."
 ## [51] "Congo, Rep."
 ## [52] "Costa Rica"
 ## [53] "Cote d'Ivoire"
 ## [54] "Croatia"
 ## [55] "Cuba"
 ## [56] "Curacao"
 ## [57] "Cyprus"
 ## [58] "Czechia"
 ## [59] "Denmark"
 ## [60] "Djibouti"
 ## [61] "Dominica"
 ## [62] "Dominican Republic"
 ## [63] "Early-demographic dividend"
 ## [64] "East Asia & Pacific"
 ## [65] "East Asia & Pacific (excluding high income)"
 ## [66] "East Asia & Pacific (IDA & IBRD countries)"
 ## [67] "Ecuador"
 ## [68] "Egypt, Arab Rep."
 ## [69] "El Salvador"
 ## [70] "Equatorial Guinea"
 ## [71] "Eritrea"
 ## [72] "Estonia"
 ## [73] "Eswatini"
 ## [74] "Ethiopia"
 ## [75] "Euro area"
 ## [76] "Europe & Central Asia"
 ## [77] "Europe & Central Asia (excluding high income)"
 ## [78] "Europe & Central Asia (IDA & IBRD countries)"
 ## [79] "European Union"
 ## [80] "Faroe Islands"

[81] "Fiji"
 ## [82] "Finland"
 ## [83] "Fragile and conflict affected situations"
 ## [84] "France"
 ## [85] "French Polynesia"
 ## [86] "Gabon"
 ## [87] "Gambia, The"
 ## [88] "Georgia"
 ## [89] "Germany"
 ## [90] "Ghana"
 ## [91] "Gibraltar"
 ## [92] "Greece"
 ## [93] "Greenland"
 ## [94] "Grenada"
 ## [95] "Guam"
 ## [96] "Guatemala"
 ## [97] "Guinea"
 ## [98] "Guinea-Bissau"
 ## [99] "Guyana"
 ## [100] "Haiti"
 ## [101] "Heavily indebted poor countries (HIPC)"
 ## [102] "High income"
 ## [103] "Honduras"
 ## [104] "Hong Kong SAR, China"
 ## [105] "Hungary"
 ## [106] "IBRD only"
 ## [107] "Iceland"
 ## [108] "IDA & IBRD total"
 ## [109] "IDA blend"
 ## [110] "IDA only"
 ## [111] "IDA total"
 ## [112] "India"
 ## [113] "Indonesia"
 ## [114] "Iran, Islamic Rep."
 ## [115] "Iraq"
 ## [116] "Ireland"
 ## [117] "Isle of Man"
 ## [118] "Israel"
 ## [119] "Italy"
 ## [120] "Jamaica"
 ## [121] "Japan"
 ## [122] "Jordan"
 ## [123] "Kazakhstan"
 ## [124] "Kenya"
 ## [125] "Kiribati"
 ## [126] "Korea, Dem. People's Rep."
 ## [127] "Korea, Rep."
 ## [128] "Kosovo"
 ## [129] "Kuwait"
 ## [130] "Kyrgyz Republic"
 ## [131] "Lao PDR"
 ## [132] "Late-demographic dividend"
 ## [133] "Latin America & Caribbean"
 ## [134] "Latin America & Caribbean (excluding high income)"
 ## [135] "Latin America & the Caribbean (IDA & IBRD countries)"
 ## [136] "Latvia"
 ## [137] "Least developed countries: UN classification"
 ## [138] "Lebanon"

[139] "Lesotho"
 ## [140] "Liberia"
 ## [141] "Libya"
 ## [142] "Liechtenstein"
 ## [143] "Lithuania"
 ## [144] "Low & middle income"
 ## [145] "Low income"
 ## [146] "Lower middle income"
 ## [147] "Luxembourg"
 ## [148] "Macao SAR, China"
 ## [149] "Madagascar"
 ## [150] "Malawi"
 ## [151] "Malaysia"
 ## [152] "Maldives"
 ## [153] "Mali"
 ## [154] "Malta"
 ## [155] "Marshall Islands"
 ## [156] "Mauritania"
 ## [157] "Mauritius"
 ## [158] "Mexico"
 ## [159] "Micronesia, Fed. Sts."
 ## [160] "Middle East & North Africa"
 ## [161] "Middle East & North Africa (excluding high income)"
 ## [162] "Middle East & North Africa (IDA & IBRD countries)"
 ## [163] "Middle income"
 ## [164] "Moldova"
 ## [165] "Monaco"
 ## [166] "Mongolia"
 ## [167] "Montenegro"
 ## [168] "Morocco"
 ## [169] "Mozambique"
 ## [170] "Myanmar"
 ## [171] "Namibia"
 ## [172] "Nauru"
 ## [173] "Nepal"
 ## [174] "Netherlands"
 ## [175] "New Caledonia"
 ## [176] "New Zealand"
 ## [177] "Nicaragua"
 ## [178] "Niger"
 ## [179] "Nigeria"
 ## [180] "North America"
 ## [181] "North Macedonia"
 ## [182] "Northern Mariana Islands"
 ## [183] "Norway"
 ## [184] "Not classified"
 ## [185] "OECD members"
 ## [186] "Oman"
 ## [187] "Other small states"
 ## [188] "Pacific island small states"
 ## [189] "Pakistan"
 ## [190] "Palau"
 ## [191] "Panama"
 ## [192] "Papua New Guinea"
 ## [193] "Paraguay"
 ## [194] "Peru"
 ## [195] "Philippines"
 ## [196] "Poland"

[197] "Portugal"
 ## [198] "Post-demographic dividend"
 ## [199] "Pre-demographic dividend"
 ## [200] "Puerto Rico"
 ## [201] "Qatar"
 ## [202] "Romania"
 ## [203] "Russian Federation"
 ## [204] "Rwanda"
 ## [205] "Samoa"
 ## [206] "San Marino"
 ## [207] "Sao Tome and Principe"
 ## [208] "Saudi Arabia"
 ## [209] "Senegal"
 ## [210] "Serbia"
 ## [211] "Seychelles"
 ## [212] "Sierra Leone"
 ## [213] "Singapore"
 ## [214] "Sint Maarten (Dutch part)"
 ## [215] "Slovak Republic"
 ## [216] "Slovenia"
 ## [217] "Small states"
 ## [218] "Solomon Islands"
 ## [219] "Somalia"
 ## [220] "South Africa"
 ## [221] "South Asia"
 ## [222] "South Asia (IDA & IBRD)"
 ## [223] "South Sudan"
 ## [224] "Spain"
 ## [225] "Sri Lanka"
 ## [226] "St. Kitts and Nevis"
 ## [227] "St. Lucia"
 ## [228] "St. Martin (French part)"
 ## [229] "St. Vincent and the Grenadines"
 ## [230] "Sub-Saharan Africa"
 ## [231] "Sub-Saharan Africa (excluding high income)"
 ## [232] "Sub-Saharan Africa (IDA & IBRD countries)"
 ## [233] "Sudan"
 ## [234] "Suriname"
 ## [235] "Sweden"
 ## [236] "Switzerland"
 ## [237] "Syrian Arab Republic"
 ## [238] "Tajikistan"
 ## [239] "Tanzania"
 ## [240] "Thailand"
 ## [241] "Timor-Leste"
 ## [242] "Togo"
 ## [243] "Tonga"
 ## [244] "Trinidad and Tobago"
 ## [245] "Tunisia"
 ## [246] "Turkiye"
 ## [247] "Turkmenistan"
 ## [248] "Turks and Caicos Islands"
 ## [249] "Tuvalu"
 ## [250] "Uganda"
 ## [251] "Ukraine"
 ## [252] "United Arab Emirates"
 ## [253] "United Kingdom"
 ## [254] "United States"


```
## [255] "Upper middle income"
## [256] "Uruguay"
## [257] "Uzbekistan"
## [258] "Vanuatu"
## [259] "Venezuela, RB"
## [260] "Vietnam"
## [261] "Virgin Islands (U.S.)"
## [262] "West Bank and Gaza"
## [263] "World"
## [264] "Yemen, Rep."
## [265] "Zambia"
## [266] "Zimbabwe"
```

Define the lists of countries by region

```

european_countries <- c("Albania", "Andorra", "Austria", "Belarus", "Belgium",
  "Bosnia and Herzegovina", "Bulgaria", "Channel Islands",
  "Croatia", "Cyprus", "Czechia", "Denmark", "Estonia",
  "Faroe Islands", "Finland", "France", "Germany",
  "Gibraltar", "Greece", "Hungary", "Iceland", "Ireland",
  "Isle of Man", "Italy", "Latvia", "Liechtenstein",
  "Lithuania", "Luxembourg", "Malta", "Moldova",
  "Monaco", "Montenegro", "Netherlands",
  "North Macedonia", "Norway", "Poland",
  "Portugal", "Romania", "Russian Federation",
  "San Marino", "Serbia", "Slovakia", "Slovenia", "Spain",
  "Sweden", "Switzerland", "Ukraine", "United Kingdom",
  "Vatican City")

african_countries <- c("Angola", "Benin", "Burkina Faso", "Burundi", "Cabo Verde",
  "Cameroon", "Central African Republic", "Chad", "Comoros",
  "Congo, Dem. Rep.", "Congo, Rep.", "Cote d'Ivoire",
  "Djibouti", "Egypt, Arab Rep.", "Equatorial Guinea",
  "Eritrea", "Eswatini", "Ethiopia", "Gabon", "Gambia, The",
  "Ghana", "Guinea", "Guinea-Bissau", "Kenya", "Lesotho",
  "Liberia", "Libya", "Madagascar", "Malawi", "Mali",
  "Mauritania", "Mauritius", "Morocco", "Mozambique",
  "Namibia", "Niger", "Nigeria", "Rwanda",
  "Sao Tome and Principe", "Senegal",
  "Seychelles", "Sierra Leone", "Somalia", "South Africa",
  "South Sudan", "Sudan", "Tanzania", "Togo", "Tunisia",
  "Uganda", "Zambia", "Zimbabwe")

asian_countries <- c("Afghanistan", "Armenia", "Azerbaijan", "Bahrain", "Bangladesh",
  "Bhutan", "Brunei Darussalam", "Cambodia", "China", "Georgia",
  "Hong Kong SAR, China", "India", "Indonesia", "Iran, Islamic Rep.",
  "Iraq", "Israel", "Japan", "Jordan", "Kazakhstan",
  "Korea, Dem. People's Rep.", "Korea, Rep.", "Kuwait",
  "Kyrgyz Republic", "Lao PDR", "Lebanon",
  "Macao SAR, China", "Malaysia", "Maldives",
  "Mongolia", "Myanmar", "Nepal",
  "Oman", "Pakistan", "Palestine", "Philippines", "Qatar",
  "Russian Federation", "Saudi Arabia", "Singapore", "Sri Lanka",
  "Syrian Arab Republic", "Taiwan, China", "Tajikistan", "Thailand",
  "Timor-Leste", "Turkey", "Turkmenistan", "United Arab Emirates",
  "Uzbekistan", "Vietnam", "Yemen, Rep.")

north_american_countries <- c("Antigua and Barbuda", "Bahamas, The", "Barbados",
  "Belize", "Canada", "Costa Rica", "Cuba", "Dominica",
  "Dominican Republic", "El Salvador", "Greenland",

```

```

        "Grenada", "Guatemala", "Haiti", "Honduras",
        "Jamaica", "Mexico", "Nicaragua", "Panama",
        "St. Kitts and Nevis", "St. Lucia",
        "St. Vincent and the Grenadines",
        "Trinidad and Tobago", "United States")

south_american_countries <- c("Argentina", "Bolivia", "Brazil", "Chile",
                              "Colombia", "Ecuador", "Guyana", "Paraguay",
                              "Peru", "Suriname", "Uruguay", "Venezuela")

oceanic_countries <- c("Australia", "Fiji", "Kiribati", "Marshall Islands",
                       "Micronesia, Fed. Sts.", "Nauru", "New Zealand", "Palau",
                       "Papua New Guinea", "Samoa", "Solomon Islands", "Tonga",
                       "Tuvalu", "Vanuatu")

# Define a function to generate a plot for a given region
generate_plot <- function(region, countries, data, country_col, file_path) {
  # Filter the dataset to include only countries in the given region
  fertility_rates_region <- data %>%
    filter(!sym(country_col) %in% countries)

  # Reshape the data from wide to long format
  fertility_rates_long <- fertility_rates_region %>%
    pivot_longer(cols = `1960`:`2021`,
                  names_to = "Year",
                  values_to = "Fertility_Rate")

  # Create the plot with custom x-axis labels
  p <- ggplot(fertility_rates_long,
              aes(x = Year,
                  y = Fertility_Rate,
                  color = !!sym(country_col),
                  group = !!sym(country_col))) +
    geom_line() +
    xlab("Year") +
    ylab("Total Fertility Rate") +
    ggtitle(paste0("Total Fertility Rate in ", region,
                   " (1960-2021)")) +
    scale_x_discrete(breaks = seq(1960, 2021, by = 5)) +
    theme(axis.text.x = element_text(angle = 45, hjust = 1),
          legend.position = "bottom") +
    guides(color = guide_legend(ncol = 3))

  # Save the plot to a file with a resolution of 400 dpi
  ggsave(paste0(file_path, "/fertility_rates_",
                 tolower(region), ".png"),
         plot = p,
         width = 14,
         height = 10,
         dpi = 200)

  return(p)
}

# Generate a plot for each region

### Figure 2 (European Countries)
generate_plot("Europe", european_countries, fertility_rates, "Country Name",

```

"~/Documents/data_analytics/fertility_rate_case_study/figures")

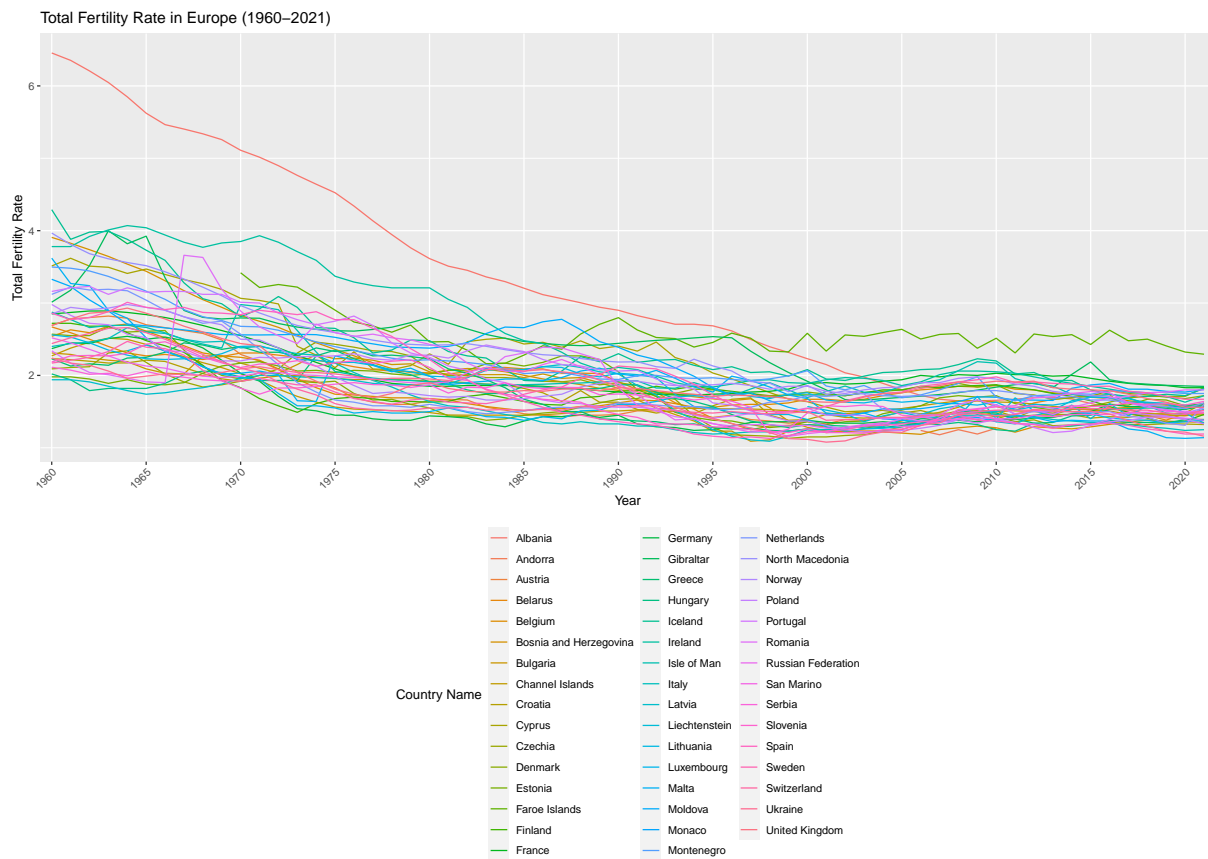


Figure 3 (African Countries)

```
generate_plot("Africa", african_countries, fertility_rates, "Country Name",
              "~/Documents/data_analytics/fertility_rate_case_study/figures")
```

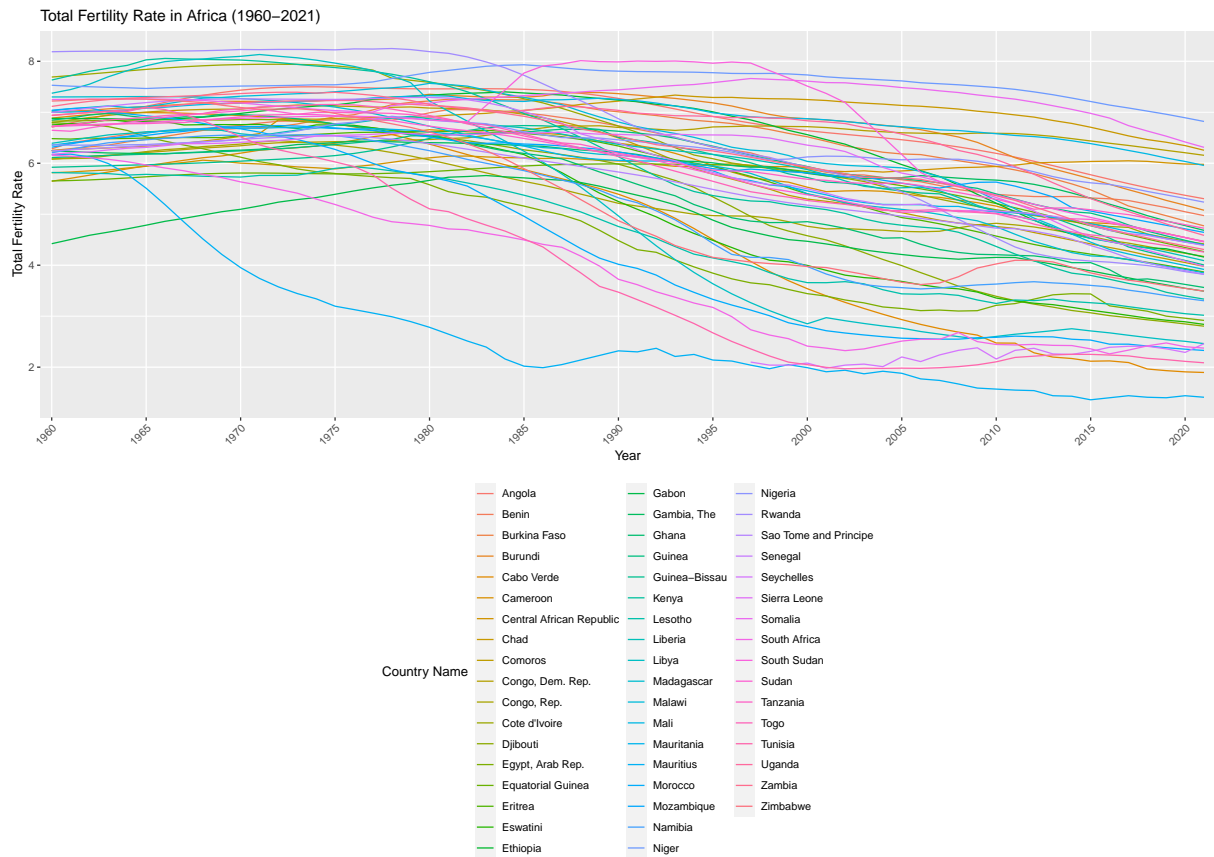


Figure 4 (Asian Countries)

```
generate_plot("Asia" , asian_countries, fertility_rates, "Country Name",
              "~/Documents/data_analytics/fertility_rate_case_study/figures")
```

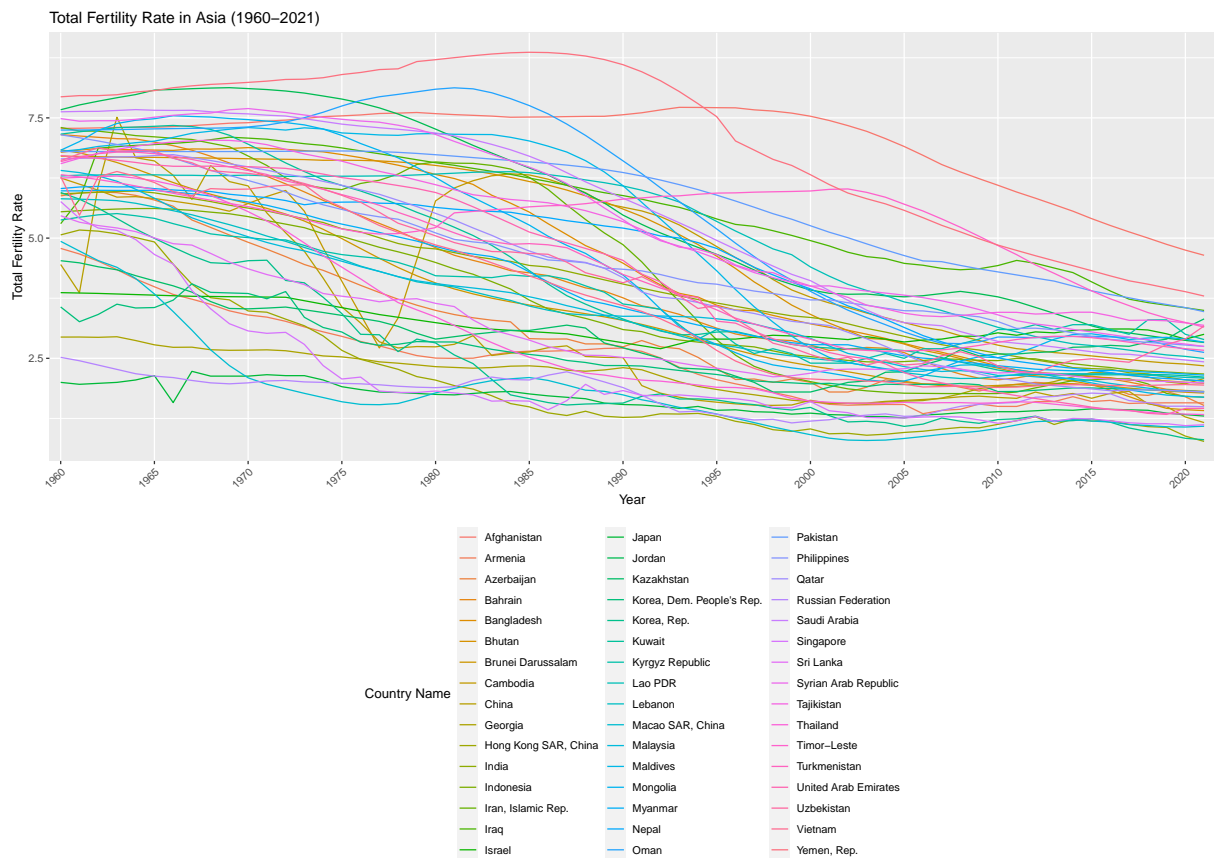


Figure 5 (North American Countries)

```
generate_plot("North America" , north_american_countries, fertility_rates, "Country Name",
              "~/Documents/data_analytics/fertility_rate_case_study/figures")
```

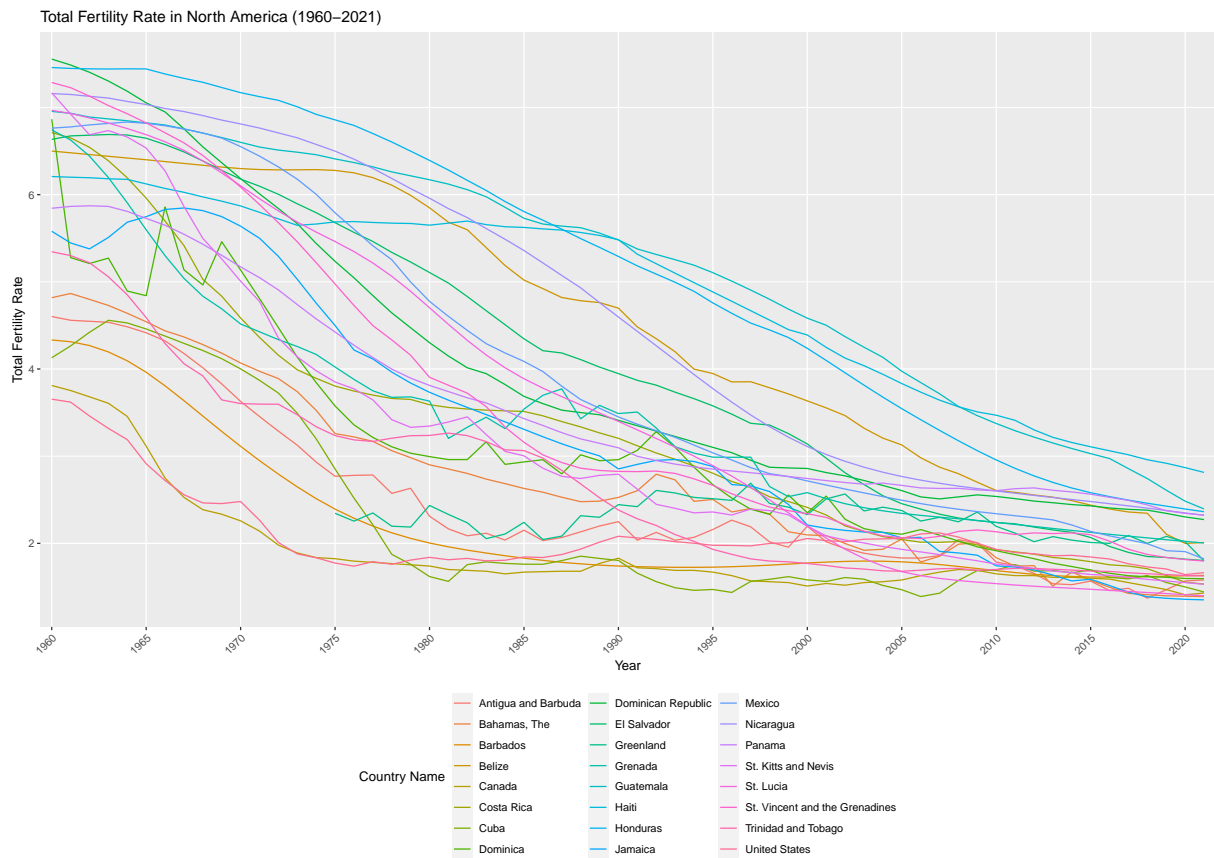


Figure 6 (South American Countries)

```
generate_plot("South America" , south_american_countries, fertility_rates, "Country Name",
              "~/Documents/data_analytics/fertility_rate_case_study/figures")
```

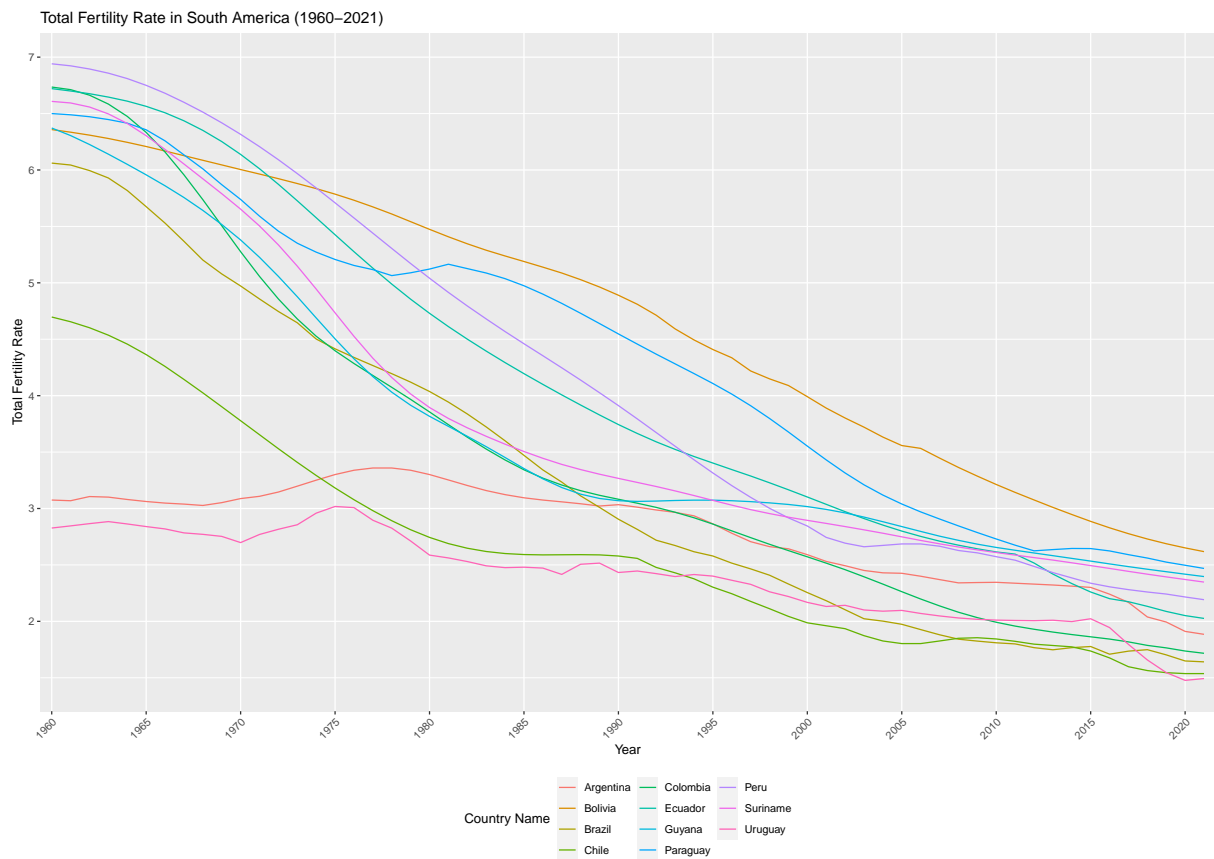
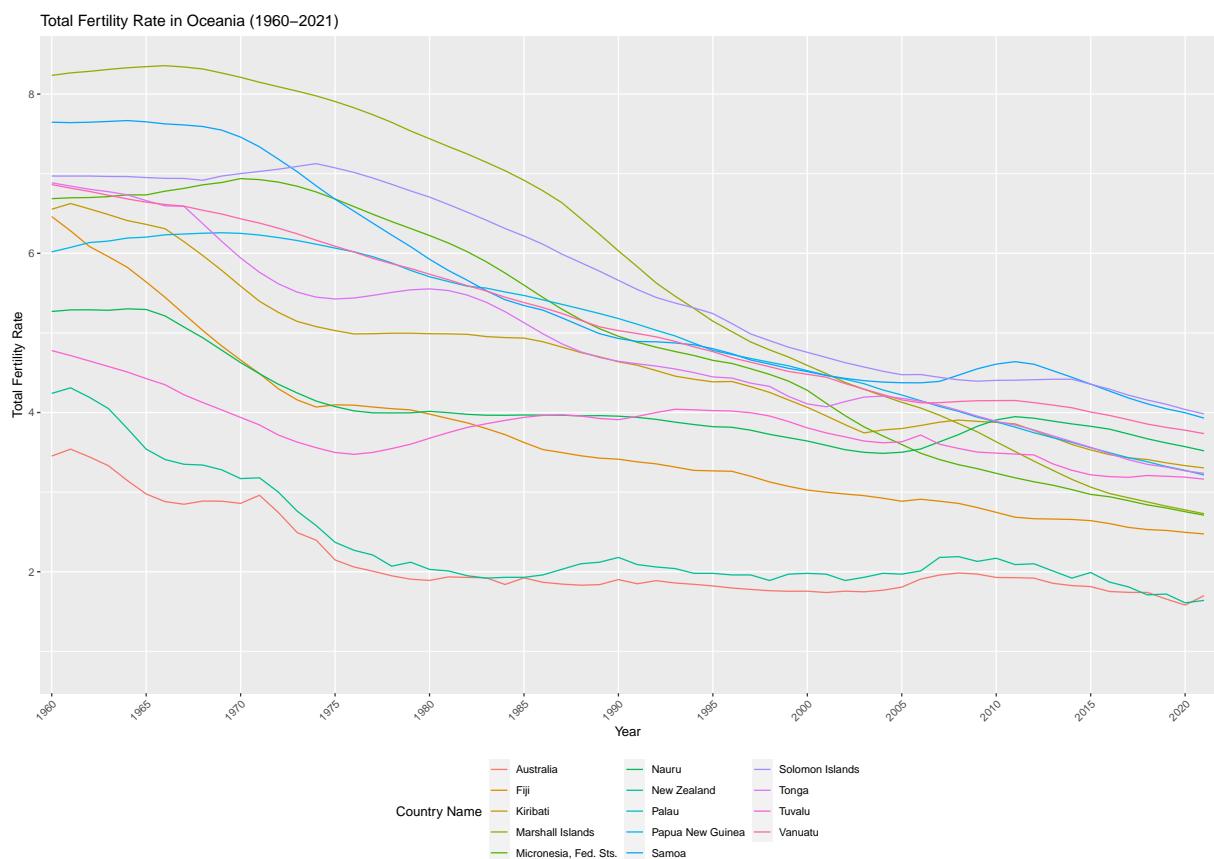


Figure 7 (Oceanic Countries)

```
generate_plot("Oceania" , oceanic_countries, fertility_rates, "Country Name",
              "~/Documents/data_analytics/fertility_rate_case_study/figures")
```



Now that we have an idea of the general trend for each region, let's aggregate these figures into one facet plot.

```
# Replace with the list of African countries
fertility_rates_africa <- fertility_rates %>%
  filter(`Country Name` %in% african_countries)

# Replace with the list of Asian countries
fertility_rates_asia <- fertility_rates %>%
  filter(`Country Name` %in% asian_countries)

# Replace with the list of European countries
fertility_rates_europe <- fertility_rates %>%
  filter(`Country Name` %in% european_countries)

# Replace with the list of North American countries
fertility_rates_north_america <- fertility_rates %>%
  filter(`Country Name` %in% north_american_countries)

# Replace with the list of South American countries
fertility_rates_south_america <- fertility_rates %>%
  filter(`Country Name` %in% south_american_countries)

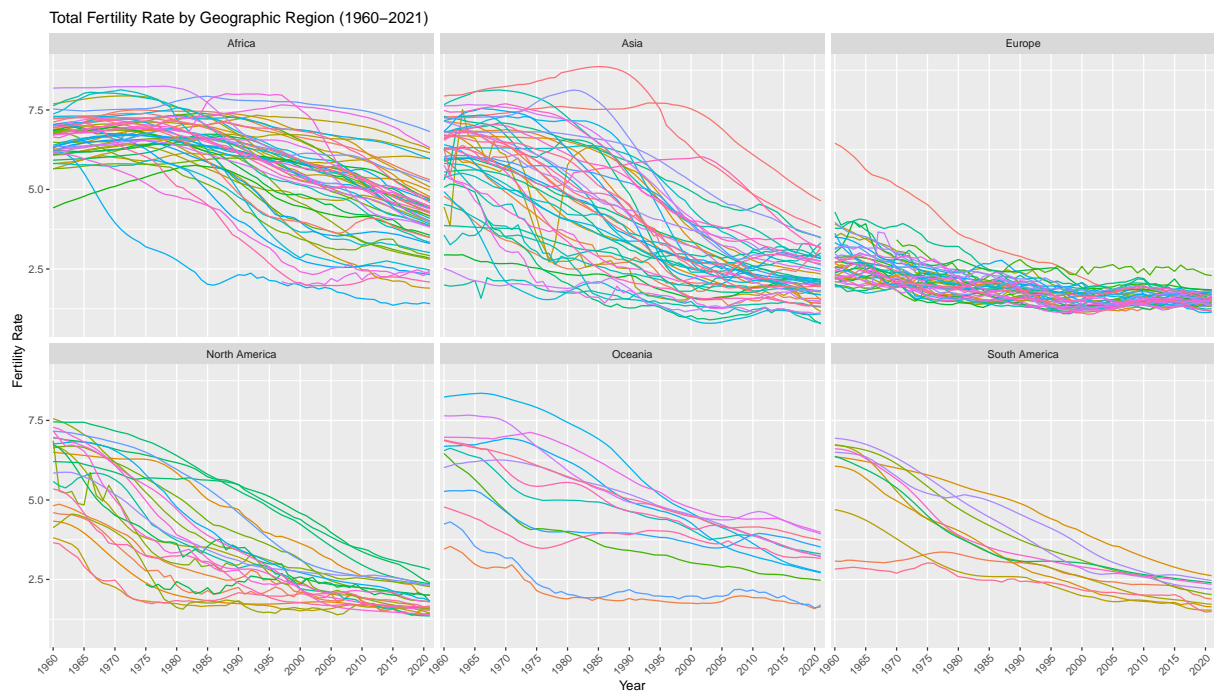
# Replace with the list of Oceanic countries
fertility_rates_oceania <- fertility_rates %>%
  filter(`Country Name` %in% oceanic_countries)

# Combine the data for all regions into one data frame
fertility_rates_all_regions <- bind_rows(
  fertility_rates_africa %>% mutate(Region = "Africa"),
  fertility_rates_asia %>% mutate(Region = "Asia"),
  fertility_rates_europe %>% mutate(Region = "Europe"),
  fertility_rates_north_america %>% mutate(Region = "North America"),
  fertility_rates_oceania %>% mutate(Region = "Oceania"),
  fertility_rates_south_america %>% mutate(Region = "South America")
)

# Reshape the data from wide to long format
fertility_rates_long <- fertility_rates_all_regions %>%
  pivot_longer(cols = `1960`:`2021`,
    names_to = "Year",
    values_to = "Fertility_Rate")

# Create the plot with custom x-axis labels and facets
p1 <- ggplot(fertility_rates_long,
  aes(x = Year,
    y = Fertility_Rate,
    color = `Country Name`,
    group = `Country Name`)) +
  geom_line() +
  xlab("Year") +
  ylab("Fertility Rate") +
  ggtitle("Total Fertility Rate by Geographic Region (1960-2021)") +
  scale_x_discrete(breaks = seq(1960, 2021, by = 5)) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1),
    legend.position = "none") +
  facet_wrap(~ Region)
```

p1



```
# Save the plot with the graphs to a file with a resolution of 400 dpi
ggsave("~/Documents/data_analytics/fertility_rate_case_study/figures/fertility_rates_all_regions_gra
      plot = p1,
      width = 10,
      dpi = 1000)
```

Saving 10 x 8 in image

This facet plot shows clearly a downward trend of total fertility rates in the last several decades; to make this data more interactive, let's create a Tableau dashboard.

Step 6: Export data, create Tableau dashboard

```
write.csv(fertility_rates_long,
          "~/Documents/data_analytics/fertility_rate_case_study/fertility_rates_all_regions.csv",
          row.names = FALSE)
```

Step 7: Explore Tableau dashboard

- [Click here to interactive with this case study's dashboard.](#)

Step 8: Identify pattern

The Tableau dashboard shows that, for nearly every country, there has been a sharp decrease in total fertility rates from 1960 to 2021. Let's quantify this result even further by finding the average percentage change in total fertility rate by country in each region from 1960 to 2021. If the average percentage change is positive for a given country, we will label it with a green circle; otherwise, we will label it with a red circle.

```
# Reshape the data from wide to long format
fertility_rates_long <- fertility_rates_all_regions %>%
  pivot_longer(cols = `1960`:`2021`,
               names_to = "Year",
               values_to = "Fertility_Rate")
```



```

# Replace spaces with underscores in column names
colnames(fertility_rates_long) <- gsub(" ", "_", colnames(fertility_rates_long))

# Add a pct_change column to the data frame
fertility_data <- fertility_rates_long %>%
  group_by(Country_Name) %>%
  mutate(pct_change = (Fertility_Rate - lag(Fertility_Rate)) / lag(Fertility_Rate) * 100) %>%
  ungroup()

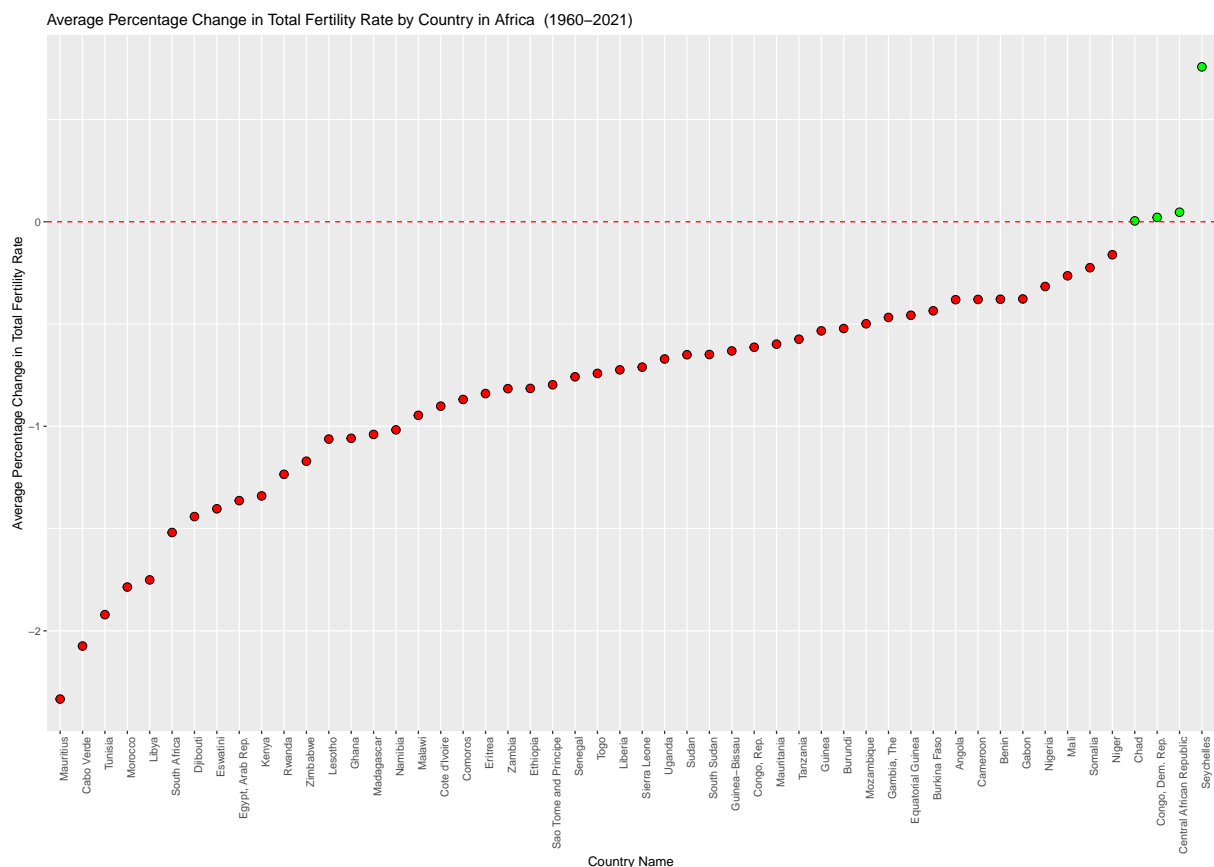
plots <- fertility_data %>%
  group_by(Region, Country_Name) %>%
  summarise(mean_pct_change = mean(pct_change, na.rm = TRUE)) %>%
  ungroup() %>%
  split(.$Region) %>%
  map(~ .x[order(.x$mean_pct_change),] %>%
    ggplot(aes(x = reorder(Country_Name, mean_pct_change), y = mean_pct_change)) +
    geom_point(shape = 21, size = 3, aes(fill = ifelse(mean_pct_change > 0, "Above 0", "Below 0"))) +
    scale_fill_manual(values = c("Above 0" = "green", "Below 0" = "red")) +
    geom_hline(yintercept = 0, linetype = "dashed", color = "red") +
    theme(axis.text.x = element_text(angle = 90, hjust = 1), legend.position = "none") +
    labs(x = "Country Name", y = "Average Percentage Change in Total Fertility Rate", title = paste(

## `summarise()` has grouped output by 'Region'. You can override using the
## `.groups` argument.

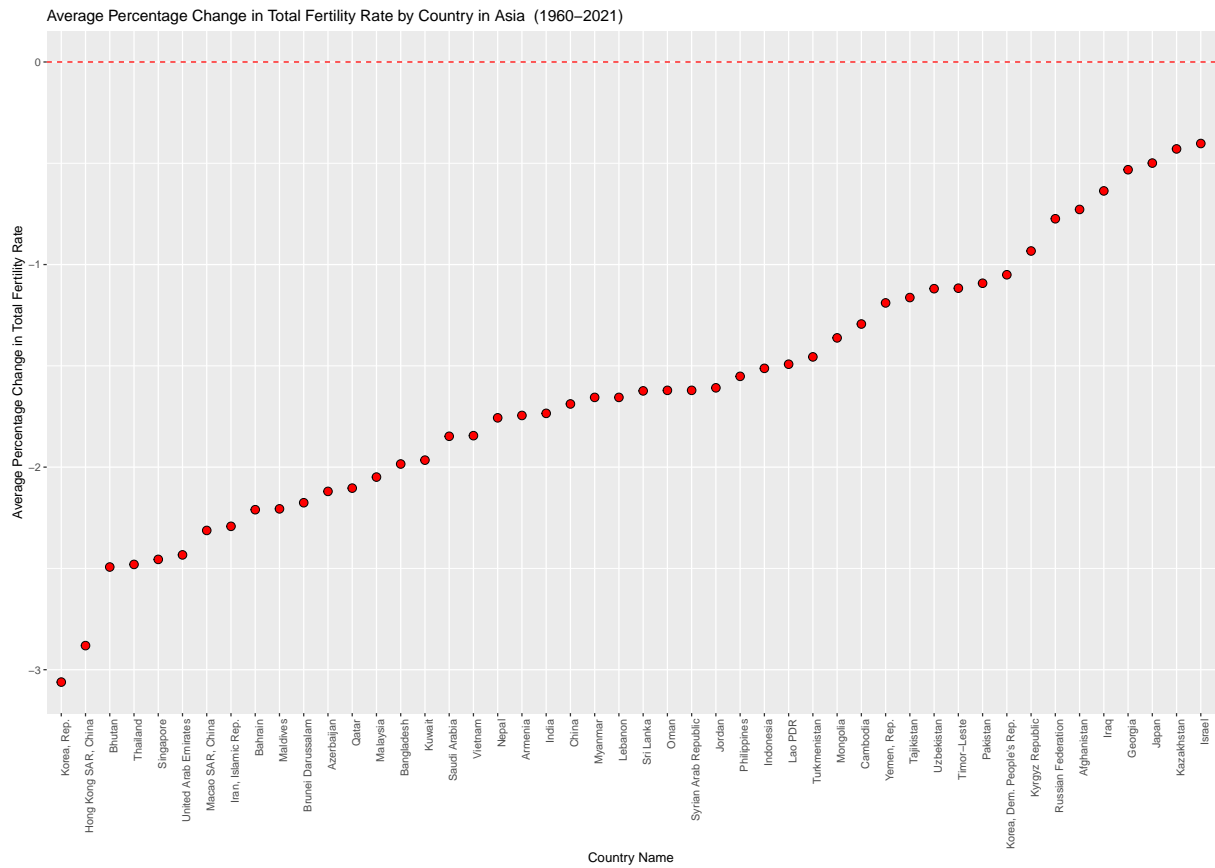
# Print the plots
plots

```

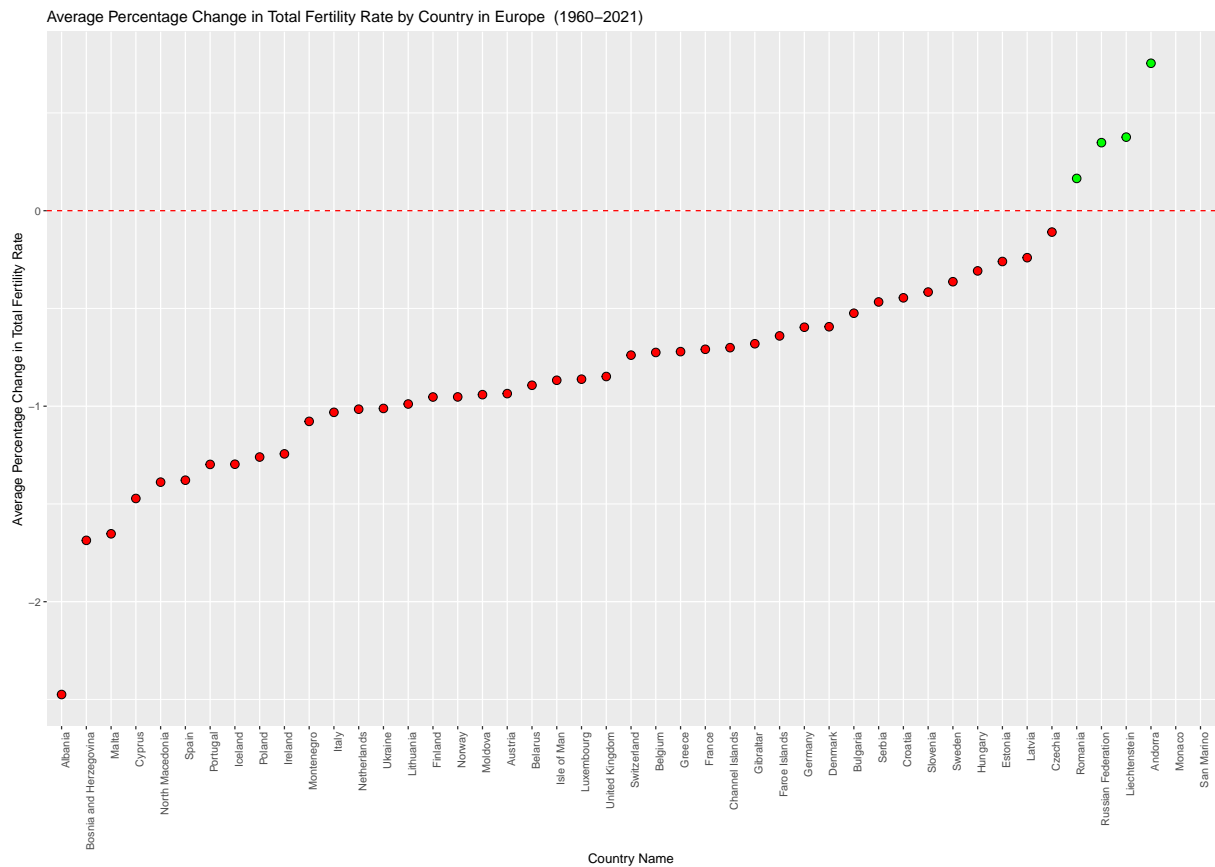
```
## $Africa
```



```
##
## $Asia
```

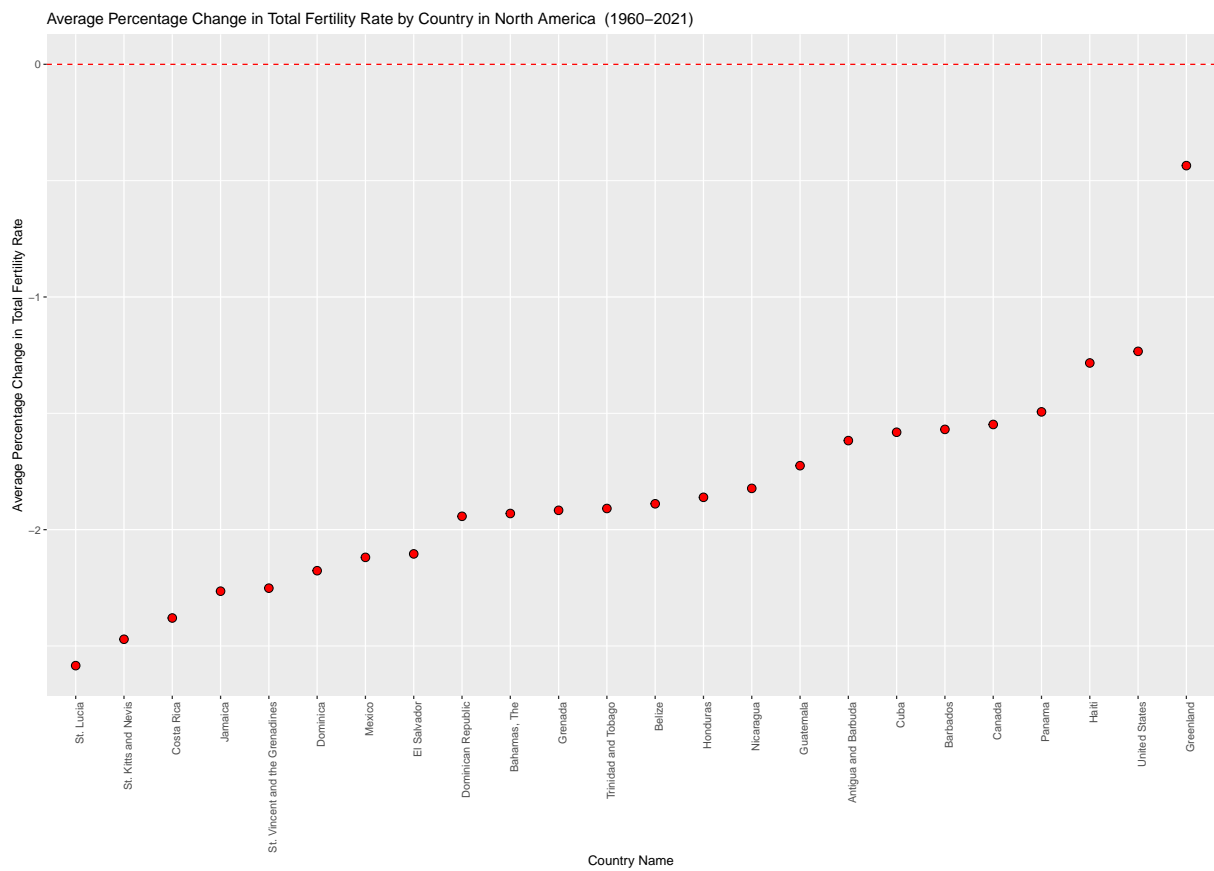


\$Europe



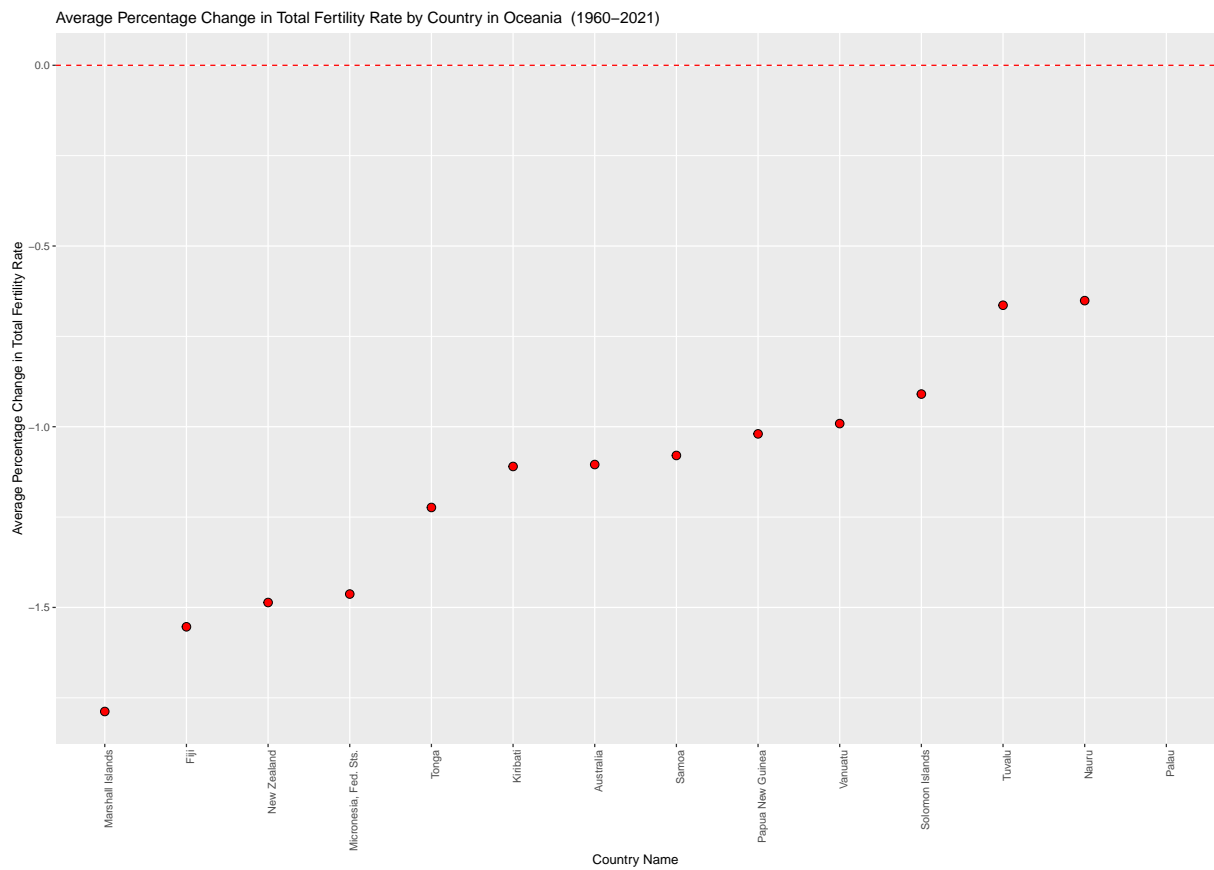
##

\$`North America`



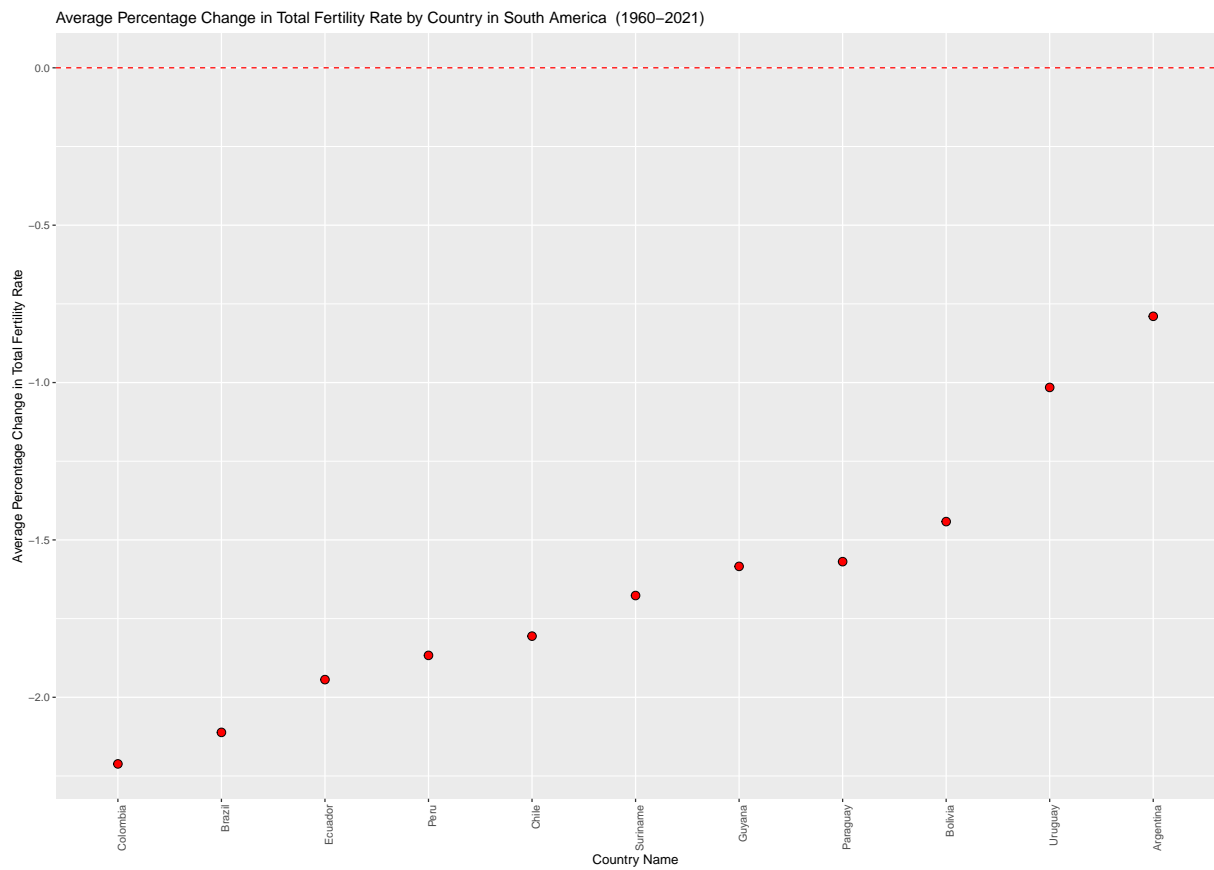
##

\$Oceania



##

\$`South America`



Conclusion These figures show that that the average percentage change in total fertility rates is negative for nearly every country from 1960 to 2021. This supports our initial hypothesis that, in the coming decades, many countries will need to address an underpopulation problem – not an overpopulation one.